

US Army Corps of Engineers

Toxic and Hazardous
Materials Agency

**Hamilton Army Airfield
Environmental Investigation/Alternatives Assessment**

FINAL SUPPLEMENTAL SAMPLING AND ANALYSIS PLAN

**Contract Number DAAA15-90-D-0008
Delivery Order Number 0002
Contract Modification 202**

Submitted to:

**U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, MD**

August 1992

Distribution unlimited approved for public release.

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SECTION 1.0

INTRODUCTION

This Supplemental Sampling and Analysis Plan (SSAP) is an addendum to the Final Sampling Design Plan (FSDP), Data Item A004, Hamilton Army Airfield, Novato, California (E.C. Jordon Co. 1990). The FSDP described sampling and data collection procedures to be utilized during the 1991 Environmental Investigation (EI) at Hamilton Army Airfield (HAA). Results of the 1991 EI (hereinafter referred to as the Phase I EI) indicated the need for a second phase of environmental investigation. The SSAP describes the sampling methods and data collection procedures to be used for Phase II of the Environmental Investigation (EI) at Hamilton Army Airfield (HAA).

1.1 PURPOSE AND SCOPE

The Phase II EI is being conducted to satisfy regulatory concerns regarding completeness of the environmental database through additional sampling. The purpose of the SSAP is to ensure that sufficient and valid data are collected to perform a risk assessment and evaluate remedial action alternatives. Principal activities to be conducted include drilling and installation of groundwater monitoring wells, sampling of various site media (e.g. soil, sediment, and groundwater), laboratory analyses of the collected samples, and entry of all chemical data into the USATHAMA IRDMIS database system.

The purpose of the investigation is: (1) to collect additional data on background concentrations of metals in the soil; (2) to obtain additional information on contamination of soil with organic compounds; (3) to obtain supplemental information on groundwater contamination by installing additional groundwater monitoring wells; and (4) to obtain additional groundwater samples in order to determine seasonal and temporal changes in groundwater quality. This information will be used to perform a more accurate risk assessment and to support the development of the Alternatives Assessment.

1.2 SUMMARY OF 1991 EI (PHASE I)

The objective of the 1991 Environmental Investigation (EI) was to acquire and analyze data necessary to define the distribution, types, and concentrations of contaminants at HAA and to assess associated risks to public health and the environment. The field investigation focused on the following areas in the Base Closure property: the Petroleum, Oil and Lubricants (POL) Area; the Revetment Area; the Pump Station Area; the Former Sewage Treatment Plant; the East Levee Landfill; the Aircraft Maintenance and Storage Area; Fuel Lines; and the Building 442 Above Ground Storage tank (AST)

Site. In addition, a study of transformer oil in transformers located throughout the base closure property was undertaken. The EI consisted of the following elements:

- Drilling and sampling of 30 boreholes
- Excavation and sampling of 11 test pits
- Installation of 28 monitoring wells
- Well hydraulic testing
- Groundwater sampling
- Soil, sediment, and seep sampling
- Transformer oil sampling
- Geophysical surveys to locate buried fuel lines
- Soil gas sampling along fuel line alignments

Information obtained during the investigation was used to interpret the type, level, and extent of contamination at HAA and to evaluate both the public health and ecological risks associated with the contamination.

1.3 PHASE II ENVIRONMENTAL INVESTIGATIONS

The proposed site investigation at HAA includes the following items:

- Acquisition of all necessary permits and utility clearances
- Near-surface soil sampling at 16 locations with a slide-hammer sampler
- Drilling and sampling of 42 drill-rig auger borings
- Drilling, soil sampling, and installing seven groundwater monitoring wells
- Two groundwater monitoring events at 17 of the existing monitoring wells and the 7 newly constructed wells.
- Sediment sampling at 8 locations
- Analyses of soil and groundwater samples using USATHAMA and/or EPA certified methods

The sites included in the Phase II investigation are:

- Background locations
- The POL area
- The Aircraft Storage and Maintenance Area
- The Revetment Area
- The Former Sewage Treatment Plant
- Building 442

Table 1.1 is a summary of the Phase II drilling and sampling program. The table shows the number of soil, sediment, and groundwater samples to be obtained in each Area.

Table 1.2 summarizes analytical methods, total number of samples, and sample sources for each of the areas included in the Phase II investigation.

The Health and Safety Plan developed for Phase I will be updated to reflect Phase I findings and then utilized for the Phase II work.

TABLE 1.1
SUMMARY OF DRILLING AND SAMPLING PROGRAM
HAMILTON ARMY AIRFIELD EI/AA - Phase II

AREA	NUMBER OF DRILL RIG AUGER BORINGS	NUMBER OF SOIL SAMPLES	NUMBER OF SLIDE-HAMMER SAMPLING POINTS	NUMBER OF SOIL SAMPLES	NUMBER OF WELLS	NUMBER OF SOIL SAMPLES	NUMBER OF SEDIMENT SAMPLES	NUMBER OF GROUNDWATER SAMPLES
POL AREA	16	32			2	2		34
AIRCRAFT STORAGE AND MAINTENANCE AREA	10	20			3	3	8	8
REVETMENT AREA	16	32			2	2		6
FORMER SEWAGE TREATMENT PLANT				8	8			
BUILDING 442					3	3		
BACKGROUND AREAS					5	15		

NOTE: This table does not include quality control samples.

TABLE 1.2
SUMMARY OF ANALYTICAL PROGRAM
HAMILTON ARMY AIRFIELD EI/AA - Phase II

AREA	SAMPLE SOURCE	MEDIA	NUMBER OF SAMPLES	VOC	SVOC	TPH	BTEX	METALS	LEAD	PESTICIDES	TOC	pH	TDS
POL AREA													
	Auger Boring	Soil	32			32	32						
	Well	Water	34			34	34						
	Well Boring	Soil	2	2		2				2	1	1	2
	Waste Drums	Soil	2			2(a)	2(a)						
AIRCRAFT STORAGE AND MAINTENANCE AREA													
	Auger Boring	Soil	20			10				20			
	Well	Water	8	8		8				8			
	Well Boring	Soil	3	3		3				3			
	Storm Drain	Sediment	8	8		8				8			
	Waste Drums	Soil	1			1(a)	1(a)						
REVETMENT AREA													
	Auger Boring	Soil	32			32	32			32			
	Well	Water	6			6	6			6			
	Well Boring	Soil	2			2	2			2	1	1	2
	Waste Drums	Soil	1			1(a)	1(a)						
FORMER SEWAGE TREATMENT PLANT													
	Hand Boring	Soil	8	8		8				8	1	1	2
BUILDING 442	Hand Boring	Soil	3			3	3			3	1	1	2
BACKGROUND	Hand Boring	Soil	15							15	1	1	2

NOTE: This table does not include quality control samples.

(a) California Waste Extraction Test (WET)

VOC - Volatile organic compounds

SVOC - Semi volatile organic compounds

TPH- Total petroleum hydrocarbon

BTEX - Benzene, toluene, ethylbenzene, xylene

TOC - Total organic carbon

TDS - Total dissolved solids

SECTION 2.0

GENERAL SITE PROCEDURES

General site procedures are described in detail in the Sampling Design Plan (E. C. Jordan Co. 1990) and are summarized below.

2.1 SITE ACCESS

HAA is an open base and, access is generally unrestricted. However, most of the buildings in the vicinity of planned field activities are abandoned and in poor condition. They are off limits to all project personnel. No one may go across or encroach upon the runway without requesting access from HAA Security.

HAA Security will be provided with the names of all field personnel and will be informed of planned activities daily by the sampling team leader during field investigations. The HAA contact is Larry Gallagher, the Army Installation Coordinator. His office location is in Building 515, Hospital Hill, HAA, and his telephone number is 415-883-3734.

2.2 DOCUMENTATION

Documentation and records required for the field investigations are described below.

2.2.1 Field Logbook

Records will be kept in the field logbook of all field activities. The information will be recorded in black, indelible ink and initialed by the author. Whenever appropriate, the information will also be entered on the appropriate data form. The logbook will document any deviations from this SSAP, the Quality Control Plan (Engineering-Science 1990), and the Health and Safety Plan, (HASP) (Engineering-Science 1990). The logbook will contain a daily record of significant events, observations, and measurements. Typical logbook entries include:

- Name and title of author, date and time of entry, and conditions
- Location and purpose of sampling activity
- Name of all field personnel and visitors
- Sample collection method, location and media sampled, number and type of samples, sample ID, and sample documentation
- Date and time of activities

- Field observations and measurements
- Documentation of scope of work changes required by field conditions

2.2.2 Field Forms

Field information and sample data will be collected on specific forms including the following which are contained in Appendix A.

- Chain-of Custody Form
- Field Boring Log
- Monitoring Well Installation Data Record
- Well Development Log
- Air Monitoring Data Form
- Groundwater Sampling Field Notes
- Daily Trip Report
- Daily Field report

2.3 FIELD INSTRUMENTATION

The following instruments will be used during field activities.

- Photoionization detector (PID)
- Water level indicator
- pH and temperature meter
- Electrical conductivity meter
- Turbidity meter

The PID will be calibrated daily before use following manufacturer's procedures using ambient air and an isobutylene gas standard. Turbidity EC, pH, and temperature instruments will be calibrated daily before use. Specifications and calibration procedures for each instrument are contained in Appendix B. Calibration will be documented in the field logbook and also on the Air Monitoring Data Form for the PID.

2.4 DECONTAMINATION

All drilling, sampling, and non-disposable personal protection equipment will be decontaminated in the field prior to use and between each sampling event to prevent cross-contamination. Specific protocols for decontamination are discussed in Section 2.5 of the Final Sampling Design Plan (E.C. Jordon Co. 1990). The following sequence will be followed for decontamination of drilling equipment (e.g. augers and tools):

- Steam cleaning
- Air drying

The following sequence will be followed for decontamination of sampling equipment:

- Scrubbing with clean water and detergent
- Double rinsing with clean water
- Air drying

Decontaminated sampling equipment will be placed in decontaminated buckets or in double-wrapped clean PVC sheeting for temporary storage.

Decontamination of drilling equipment will be carried out at the steam-cleaning trailer. Planned locations for the steam-cleaning trailer are designated in the POL Area, at the Aircraft Storage and Maintenance Area, and in the Revetment area. All decontamination water will be obtained at Building 736 of the POL Area from the hose bib labeled #1. This water was previously sampled for VOCs and ICP metals (Engineering-Science 1991) and approved by USATHAMA for decontamination. Two additional samples of this water will be obtained prior to initiation of sampling activities and analyzed for VOCs, SVOCs, TPH, metals, and pesticides.

2.5 DISPOSAL OF CONTAMINATED MATERIAL

Drill cuttings will be stored in Department of Transportation (DOT) approved 55-gallon steel drums and stored at the drilling sites. Decontamination fluids (rinse water) will be stored in DOT approved 55-gallon steel drums at the decontamination sites. Purge water that is bailed or pumped from the monitoring wells will be stored in DOT approved 55-gallon steel drums and stored at the monitoring well sites. Soils, rinse water, and groundwater will be drummed separately. Contaminated disposable personal protective equipment will be containerized in DOT approved drums separately from soil and water. Drum contents will be identified with weather resistant labels attached to the drum exteriors. Labels on drums will specify as a minimum: the exploration location, date, and drum contents. Label entries will be made in indelible ink or paint.

A record will be maintained of the drums and their contents. At the conclusion of sampling activities ES will assist the base Environmental Coordinator with identifying disposal options.

2.6 PERMITS

Permits for the monitoring wells will be filed with the Marin County Department of Health and Human Services. The permitting point of contact is Mr. Arthur Marthinsen, (415) 499-6907. A representative of Marin County Environmental Health and Services will be kept apprised of drilling and well completion activities in order to schedule on-site inspections.

All drill sites will be cleared for underground utilities by the Navy Public Works Center (PWC), Oakland prior to start of drilling. Points of contact for the Navy PWC are John Domingus (510) 302-6870 and Bob Gates (510) 302-6171.

SECTION 3.0

ENVIRONMENTAL SAMPLING PROCEDURES

3.1 SOIL AND SEDIMENT SAMPLING PROCEDURES

Soil sampling will generally be accomplished either by a truck mounted hollow stem auger drill rig equipped with a Modified California split-spoon sampler or by using a hand auger or shovel and manual slide hammer sampler. The Modified California sampler contains three metal tubes, each 6 inches in length and 2 inches in diameter, to collect samples. The slide hammer sampler uses a single metal tube, 6 inches long and 2 inches in diameter, to collect samples. The slide hammer sampler will be used where exploration depths are approximately 5 feet or less and where the site soils can be penetrated with a shovel or hand auger. Stainless steel tubes will be used to collect soil samples to be analyzed for metals and brass tubes will be used to collect samples for all other analytical methods.

All other manual sampling tools that contact the soil will be made of Teflon or stainless steel.

Groundwater monitoring wells will be drilled using a hollow-stem auger or by air rotary drilling methods (as is expected in the POL Area).

3.1.1 Borehole Logging

Borehole samples will be logged from examination of either auger cuttings or split-spoon samples; or air rotary discharge line cuttings depending on the drilling method utilized. The field geologist will describe and classify subsurface soil and rock types following standards outlined in ASTM D-2487 and D-2488 (Appendix C). The field geologist will record the following basic information on the heading of the Boring Log Form (Appendix A):

- Project name and number (Hamilton Army Airfield Phase II, NC282)
- Boring number
- Name of drilling contractor and driller
- Drilling method
- Casing size
- Start and finish dates
- Name of geologist

- Protection level
- Total depth
- Screened interval
- Soil depth

The following technical information will also be recorded on the log:

- Organic vapor readings and indications of contamination (odor or color)
- Blow counts
- Depth to groundwater
- Water depth and time of measurement at completion
- Significant observations about drilling rate, equipment operation, or unusual conditions
- Soil classification and description

Soil will be classified in accordance with the Unified Soil Classification System (USCS). The description should include the following as appropriate:

- Color
- Soil name; gravel, sand, silt, or clay
- Grain shape
- Mineralogy
- Moisture
- Compactness/Consistency
- Plasticity
- Other descriptive information (staining, odor, organic content, etc.)

3.1.2 Soil Sampling and Headspace Screening

3.1.2.1 Modified California Split Spoon Sampling

Headspace samples will be collected from split-spoon sample tubes not utilized for laboratory analysis and placed in sealable-plastic storage bags. After the sample bag has been left for approximately 3 minutes, a PID probe will be inserted through the opening. The reading of the PID will be recorded in the Air Monitoring Form and on the Boring Log. Metal sample tubes retained for laboratory analysis will be quickly removed from the sampler and the ends of the tube will be covered with Teflon tape and then capped with non-reactive plastic caps immediately upon opening the sampler. A label with the proper sample information will be affixed to the tube. Tubes shall not be sealed with adhesive tape. The tube will then be placed in a sealable plastic storage bag and stored in a cooler with blue ice.

3.1.2.2 Slide Hammer Sampling

The ends of the sample tube will be covered with Teflon tape and then capped with non-reactive plastic caps. A label with the proper sample information will be affixed to the tube. Tubes shall not be sealed with adhesive tape. The tube will then be placed in a sealable plastic storage bag and stored in a cooler with blue ice.

3.1.2.3 Air Rotary Sampling

Samples of air rotary cuttings will be placed in decontaminated 500 ml glass amber wide-mouth jars supplied by the laboratory. The jars will be completely filled with cuttings. A label with the proper sample information will be affixed to the jar. The jar will then be placed in a sealable plastic storage bag and stored in a cooler with blue ice.

3.1.2.4 Sediment Sampling

Sediment samples will be obtained from eight storm drains in the Aircraft Storage and Maintenance area. The grates to the storm drains will be removed and the sediment sample obtained using a long handled decontaminated scoop made of Teflon or stainless steel. The sample will be transferred to a decontaminated 500 ml glass amber wide-mouth jar supplied by the laboratory. The jars will be completely filled with sediment. A label with the proper sample information will be affixed to the jar. The jar will then be placed in a sealable plastic storage bag and stored in a cooler with blue ice.

3.1.3 Sample Designation

Samples will be assigned a 10-character site identification and four-character site-type designation in accordance with the Sampling Design Plan (E.C. Jordon Co. 1990).

3.1.4 Sample Preservation and Handling

All soil, water, rock cuttings, and sediment samples will be containerized and preserved in the field according to the methods listed in Table 3.1. All water sample containers and sediment containers will be pre-cleaned by the laboratory in accordance with procedures described in Appendix G of the USATHAMA Quality Assurance Program (QAP) (1990). All groundwater sample containers will be triple rinsed with sample water prior to sampling (rinse bottles for filtered samples with filtered sample water). Soil sampling sleeves will be cleaned by the supplier prior to use.

Samples for metals analysis will be field filtered before preservation; filtering protocols are as follows:

- Samples will be filtered through a 0.45 um positive pressure disposable membrane filter; vacuum filtration shall not be used.
- Samples shall be filtered immediately after collection. Exposure of samples to the atmospheric will be kept to a minimum (i.e., do not leave containers uncapped when not necessary).

Preservation of samples with acid will be accomplished immediately after obtaining the sample. The precise quantities of preservatives will be determined by measuring pH on acidified sample water using spare containers.

TABLE 3.1
SAMPLE CONTAINERS, VOLUMES, PRESERVATION, AND HOLDING TIMES
HAMILTON ARMY AIRFIELD E/AA - Phase II

MEDIUM	PARAMETER	USATHAMA METHOD #	EQUIVALENT EPA METHOD	REQUIRED SAMPLE VOLUME	SAMPLE CONTAINER	PRESERVATIVE	HOLDING TIME
Soils/Sediments	TCL VOCs	LM23	8240	100 g(a)	BSS/GA	4 deg C	14 days
	TCL SVOCs	LM25	8270	100 g(a)	BSS/GA	4 deg C	7/40(d)
	TPH	NA	418.1	100 g(a)	BSS/GA	4 deg C	7/40(d)
	BTEX	AA9	8020	100 g(a)	BSS/GA	4 deg C	14 days
	TAL Inorganics						
	ICP Metals	JS12	6010	100 g(a)	SST/GA	4 deg C	6 mo
	Mercury	Y9	7471	100 g(a)	SST/GA	4 deg C	28 days
	Arsenic	B9	7060	100 g(a)	SST/GA	4 deg C	6 mo
	Selenium	JD20	7740	100 g(a)	SST/GA	4 deg C	6 mo
	Lead	JD12	7421	100 g(a)	SST/GA	4 deg C	6 mo
	Cyanide	KF15	9010	100 g(a)	SST/GA	4 deg C	14 days
	Pesticides	LH17	8080	100 g(a)	BSS/GA	4 deg C	7/40(d)
	TOC	NA		100 g(a)	BSS/GA	4 deg C	28 days
	pH	NA		100 g(a)	BSS/GA	NR	
Groundwater	TCL VOCs	UM21	8240	3x40 ml	VOA	4 deg C, pH<2, HCl	14 days
	TCL SVOCs	UM25	8270	2x1000 ml	GA	4 deg C	7/40(d)
	TPH	NA	418.1	1000 ml	GA	4 deg C, pH<2, HCl	7/40(d)
	BTEX	AV8	8020	3x40 ml	VOA	4 deg C, pH<2, HCl	14 days
	TAL Inorganics						
	ICP Metals	SS12	200.7	500 ml (b)	P	4 deg C, pH<2, HNO3, (c)	6 mo
	Mercury	CC8	245.1	500 ml (b)	P	4 deg C, pH<2, HNO3, (c)	28 days
	Arsenic	AX8	206.2	500 ml (b)	P	4 deg C, pH<2, HNO3, (c)	6 mo
	Selenium	SD25	270.2	500 ml (b)	P	4 deg C, pH<2, HNO3, (c)	6 mo
	Lead	SD18	239.2	500 ml (b)	P	4 deg C, pH<2, HNO3, (c)	6 mo
	Cyanide	TF34	335.3	1000 ml	P	4 deg C, 2 ml NaOH, pH>12	14 days
	Pesticides	UH20	8080	1000 ml	GA	4 deg C	7/40(d)
	TDS	NA	160.1	125 ml	P	4 deg C	7 days
	BSS - Brass sampling sleeve SST - Stainless steel sampling sleeve P - Polyethylene GA - Glass amber bottle with Teflon-lined cap G - Glass bottle with Teflon-lined cap HCl - Hydrochloric acid HNO3 - Nitric acid NaOH - Sodium hydroxide						
	TAL - Target analyte list TCL - Target Compound list VOA - 40 ml glass vial with Teflon septum VOCs - Volatile organic compounds SVOCs - Semi volatile organic compounds TPH - Total petroleum hydrocarbons (a) All (a) analyses can be determined from one sample container. (b) All (b) analyses can be determined from one sample container. (c) - Metals samples must be field filtered before preservation. (d) - Seven days for extraction and 40 days from extraction to analysis						

The collected samples and their containers present a mechanism for personnel and environmental exposure. Samples must be maintained within the sample container; no leakage should be allowed to occur during transport, and no residue should be present on the exterior of the sample container.

3.1.5 Sample Labeling

Sample labels will be attached to all samples. The sample labels will include the site ID number, site type designation, sample number, date, time (24-hour clock), samplers name, and analyses.

3.1.6 Sample Custody

Field personnel will follow Chain-of-Custody Procedures as discussed in Section 7 of the USATHAMA QAP (1990) in order to assure that all environmental samples are accounted for at all times. Information entered on the chain-of-custody forms (COC) must also be included in the field log. All entries must be legible and made in indelible ink (blue or black). The following information is required as a minimum:

- Sample date and time
- Sample location
- Field sample number
- USATHAMA Site ID number
- USATHAMA Sampling Method Code
- USATHAMA-defined sample depth
- Field duplicate, trip or rinse blank codes as appropriate
- Required analyses
- Preservative
- Sampler's name

All samples must be maintained within the custody of the sampling personnel at all times (i.e., within possession or within view of the sampler or within a designated secure area). Samples will be maintained in such a manner which will prevent or detect tampering if it occurs. Every sample container must have a signed, dated custody seal that overlaps the lid and the container. Sample containers will be packed and sealed in the following manner:

- Line ice cooler with a heavy-duty plastic bag and tape the drain plug closed.
- Wrap individual sample bottles in bubble pack and place bottles in sealable plastic bags.
- Double wrap blue ice in sealable plastic bags. Put blue ice around samples. Fill all remaining space with bubble pack to prevent sample movement. Make sure there is enough bubble pack around samples to prevent direct contact between the blue ice and sample container.

- Place the COC Record in a sealed plastic bag and secure the COC Record to the inside top of the sample container with tape. Securely tape the cooler closed with fiber tape.
- Ensure that all cooler lids are tight and then seal the lid to the cooler with custody tape. The custody tape must be in direct contact with the cooler, not the fiber tape.

Samples should be delivered to the Federal Express office at Larkspur Landing (closing time 17:15). Call Fed Ex before noon for arrangements to have sample coolers picked up on-site (zipcode is 94949). Do not leave cooler unattended.

Samples will be shipped by Federal Express to:

DataChem Labs
960 W. Le Voy Drive
Salt Lake City, UT 84123
801-266-7700
Sample Receipt: Dave Gayer

3.1.7 Chain of Custody Record

The Chain of Custody Record (COC) (Appendix A) must accompany the samples at all times and is sent with the samples to the analytical laboratory. One copy of the COC Record will be given to the Project Manager and a second copy will be retained in the project files. The following procedures will be used for COC Records:

- The originator shall fill in all information on the form in indelible ink. Note on form that all analyses are to be completed in accordance with USATHAMA-certified methods. For the sample location, substitute the USATHAMA ID number.
- The person taking custody shall check the sample label information against the COC Records and also check the sample condition and note any evidence of tampering or degradation.
- Persons initiating or receiving the samples shall clearly indicate the time and date of transfer.

3.1.8 Boring Abandonment

Upon completion, borings which are not to be converted into monitoring wells will be backfilled to the ground surface with 20:1 cement-bentonite grout. The grout used will be an organic-free, moderate pH, high solids bentonite specifically designed for sealing environmental monitoring wells and borings. A maximum of 8 gallons of water per 94-pound bag of cement will be used.

3.2 GROUNDWATER MONITORING WELL PROCEDURES

This section describes the general procedures associated with installation and development of groundwater monitoring wells. All drilling, lithologic logging, and monitoring well construction activities will be supervised by a California Registered Geologist, or by a subordinate employee under his direct supervision.

3.2.1 Groundwater Monitoring Well Installation

Seven groundwater monitoring wells will be installed at HAA in conjunction with the Phase II activities. Primary direction for monitoring well construction is given in the USATHAMA Geotechnical Requirements (USATHAMA 1987). Other well construction standards that may be applicable include the California Department of Water Resources (DWR) Standards (DWR 1991) and California Department of Toxic Substances Control (DTSC) Standards (DTSC 1990). Because of the shallow depth to groundwater at the site, well installation specifications will be modified where necessary to accommodate site conditions. Only modifications approved by USATHAMA Geology Branch for the installation of the existing monitoring wells are permitted. These modifications are described in the following sections. The well construction materials used for construction of the existing monitoring wells were also approved by USATHAMA. Similar materials are proposed for the Phase II well installations and are subject to USATHAMA approval. Samples of these materials which include bentonite pellets, bentonite, and granular backfill will be sent to USATHAMA for approval prior to use. Only USATHAMA approved materials shall be used for well construction.

Monitoring wells will be constructed of new and decontaminated 4-inch ID, Schedule 40, flush threaded polyvinyl chloride (PVC) screen and riser pipe. Well screens and risers will be steam-cleaned prior to installation by the drilling contractor in accordance with procedures discussed in Section 2.4. The monitoring wells will be screened at a sufficient depth to collect representative groundwater samples and screened to intercept contaminants that may be floating on the water table. The wells will be screened so as to allow for seasonal and/or tidal fluctuations in the water table. The lower portion of each well will be screened over a length of 10 feet or greater. Well screen will be 0.01-inch factory slotted. A threaded PVC plug will be placed at the bottom of the well.

The annulus around all well screens will be backfilled with a clean Monterey #2/12 sand. The sandpack will extend from a maximum of three feet below the bottom of the well screen to a minimum of 5 feet above the well screen if possible. However, for most of the well installations, the shallow depth of the groundwater table will not allow the full 5 feet of sand cover above the well screen or five feet of bentonite seal normally required by the Geotechnical Specifications (USATHAMA 1987). Where the full 5 foot sandpack and seal cannot be obtained, two foot sections will be utilized. If depth to groundwater permits, a 5-foot bentonite pellet seal will be placed above the sand pack. Bentonite seals will be hydrated by addition of site decontamination water prior to placement of grout. A minimum of one hour will be allowed for the hydration of the bentonite before the cement seal is placed.

Portland Type I-II cement with Monterey #2/12 sand (approximate 1:1 mix) with a maximum admixture of 5 percent approved bentonite will be placed into the annulus above the bentonite pellet seal. Because of the shallow depth of the bentonite seal expected at most of the monitoring well locations, installation of the grout seal by the tremie method will not be practical or effective. Grout will be composed of equal amounts of sand and cement, (no more than 5 percent) bentonite by weight, and a maximum 8 gallons of water per 94 pound bag of cement. Bentonite will be added after

mixing the cement and water. The sand will be added to the grout to assure a more durable surface seal.

A loose fitting unthreaded 5-inch PVC cap will be installed at the top of the riser. An eight-inch steel protective casing will be installed and sealed into the ground over the well riser so that the top of the protective casing protrudes no more than 0.2 feet above the riser. The protective steel casings will be brush-painted orange, clearly labeled using white paint with the well number and equipped with locking covers. Monitoring well riser will extend approximately 2 1/2 feet above the ground surface. A grout collar will be installed within each protective casing to 0.5 feet above ground surface. The steel protective casing will have a 1/4" weep hole located 1/2" above the grout collar to allow water to drain from the annular space between the protective casing and the inside monitoring well casing.

The ground surface around the casing will be prepared so as to secure the casing, prevent surface runoff from entering the borehole, and direct runoff away from the casing. At most locations these criteria will be met by existing compacted gravel, pavement at the surface, or other site fill materials. Where site conditions do not meet the above stated objectives, a 4-foot by 4-foot concrete pad will be placed around the well.

The well shall be secured as soon as possible after drilling. A corrosion-resistant lock, keyed-alike to EI Phase I wells, shall be provided for the monitoring well locking lid assembly. The well key will be delivered to the base Security Officer, Mr. Larry Gallagher, Building 515, HAA following completion of the field effort.

Following installation of each groundwater monitoring well, a Monitoring Well Installation Data Record will be completed which contains the following information:

- Project name and number
- Supervising geologist or engineer
- Well installation date
- Borehole diameter and depth
- Description, dimensions, and depths of all well construction materials (including casing, screen, filter pack, bentonite seal, and cement grout).
- Depth of first-encountered groundwater and stabilized groundwater depth below ground surface, with dates of measurements.

A written record of construction detailing the timing, amount of materials, and methods of installation for each step of monitoring well construction shall be prepared and recorded in the field logbook. If the well is in a location that is exposed to traffic, up to four protective 3" steel pipe pickets will be installed around the well head according to the Geotechnical Requirements.

3.2.2 Monitoring Well Development

The groundwater monitoring well will be developed no sooner than 48 hours after completion of well installation activities to allow for grout curing. The preferred

development technique shall be by vented surge block; alternative surging and bailing methods for well development may also be acceptable depending on the capacity of the well. The following procedures shall be followed for well development by vented surge block:

- Surging will begin at the bottom of the well screen.
- The surge block assembly shall be raised and lowered ten times over a one-foot interval across the well screen. The surge block will then be raised to the next one foot of screened interval and the process repeated.
- Following surging of the entire screened interval, the surge block assembly shall be removed from the well, and one well bore volume shall be purged from the well, if possible. A submersible pump or a large production bailer hung from the drill rig mast will be used for initial well purging.
- If necessary, ES field crews will finish purging using either electrical submersible pumps or Teflon hand bailers following the drilling subcontractor's bail down effort.
- Turbidity will be measured periodically as an indicator of TDS and water quality.
- The goal for development well volume is 5 times the volume of standing water in the casing just prior to development plus 5 times the water contained in the filter pack calculated according to the USATHAMA Geotechnical Requirements.
- Should recharge be so slow that the required volume cannot be removed in 48 consecutive hours, an alternate USATHAMA approved protocol will apply. This is the same presample purging protocol described in Section 3.2.5 below.

Sediment shall be removed from the bottom of the monitoring well insofar as possible by bailing. No detergent, soap, acids, bleach, or other additives shall be used in well development. All development equipment shall be decontaminated following protocols discussed in Section 2.4.

The static water level will be measured in the groundwater monitoring well immediately before development and after the water level has stabilized. The static water level will be measured following protocols discussed in Section 3.2.4 and recorded on the Well Development Log form (Appendix A), and the field logbook (Section 2.2.1.).

The total volume of groundwater purged from each well during development will be determined by direct measurement in containers of known volume or by using a calibrated flow meter. Development water volumes shall be recorded on the Well Development Log form and in the field notebook (Section 2.2).

For each well, a one-pint sample of the last water to be removed during development will be collected and saved off site for possible examination by USATHAMA's geologist until further notice. No sample preservation is required.

3.2.3 Monitoring Well Elevation and Location Survey

Horizontal and vertical location coordinates of the new groundwater monitoring wells will be surveyed by a California licensed land surveyor. The location of the groundwater monitoring well will be measured relative to a reference location such as a bench-mark or previously surveyed well head. Several benchmarks have been provided by previous surveying contractors. The survey shall have a precision of ± 3 feet horizontal and ± 0.05 foot vertical and shall utilize an x-y coordinate system to identify the well location. The x-coordinate is the north-south axis and the y-coordinate is the east-west axis. Coordinates will be calculated in the Universal Transverse Mercator (UTM) system as required by USATHAMA specifications.

3.2.4 Groundwater Level Measurements

Static water level measurements will be collected from all groundwater monitoring wells located within the same site area (e.g., POL, Revetment, Aircraft Maintenance) within an 8 hour period. Static water levels shall also be collected at each well both prior to and after each round of groundwater sampling. Water level measurements will be collected using an electronic water level indicator. Water level indicators will be decontaminated prior to use and between each monitoring well following protocols discussed in Section 2.4. The initial static water level measurement will be made before any fluids are withdrawn from the well and before any equipment enters the well. Specific procedures for collection of static water level measurements are as follows:

- Decontaminate water level probe following protocols discussed in Section 2.4.
- Remove well cap and obtain PID reading.
- Slowly insert water level probe into the well until the alarm on water level indicator sounds.
- Slowly lower and raise the probe to determine precise water level. The reading is made at the intersection of the fixed mark (notch) on the top of the inside 4-inch diameter well casing and the tape of the sounder. Record static water level to the nearest 0.01 feet.
- Turn off water level indicator between wells.

The static water level at the first well tested at each site shall be measured three times within a 5 minute interval to establish measurement precision. The measured water level in all wells will be checked against previous water level readings if available. If discrepancies exist in the two water level readings, the water level will be measured again. Water level measurements shall be recorded on Water Level Data Sheets and in the field logbook (Section 2.5). Water levels will be recorded as depth in feet from casing reference mark to top of water. **IMPORTANT:** The sample depth noted on the chain-of-custody form must be depth below ground surface of the water level prior to sampling. Therefore, subtract stickup height from measured water levels. "Stickup height" is defined as the height above the ground surface of the water level measurement point on the inner well casing.

3.2.5 Monitoring Well Pre-Sample Purging

Groundwater sampling may commence no sooner than 72 hours (3 days) after completing well construction. This variance (Plank 1990) that was granted by USATHAMA and supersedes specifications in the Technical Plan and the USATHAMA Geotechnical Requirements.

A submersible pump or Teflon bailer will generally be used for well purging. All well purging equipment (submersible pump, hose, bailers and water level indicator) shall be decontaminated prior to use as discussed in Section 2.4. The USATHAMA Geotechnical requirements state that five well volumes should be purged from the well prior to groundwater sampling. One well volume (V) in gallons is calculated as follows:

Where H = Height of standing water in sand pack (total well depth in feet from top-of-casing minus static water level in feet measured from top-of-casing).

For a 4 inch diameter well, the well casing volume in gallons is $1.7H$.

Purge pump intakes shall be equipped with a positive flow check valve to prevent purge water from flowing back into the well. Purging and sampling shall be performed in a manner which minimizes the agitation of sediments in the formation. Submersible pumps and bailers shall not be allowed to free-fall into the well.

The temperature, pH, electrical conductivity (EC) and turbidity of the purge water shall be measured prior to purging, at least twice during purging, and once after completion of purging to establish aquifer stability. These parameters shall be recorded on the Groundwater Sampling Field Notes form (Appendix A) and in the field logbook (Section 2.2.1). Purge water parameters will be measured in clean rinsed glass containers.

Most of site monitoring wells are screened in Bay Mud or rock having extremely low hydraulic conductivity. In Phase I field investigations it was found that water levels generally recharged too slowly to allow timely purging of the five well volumes specified in the USATHAMA Geotechnical Requirements (March 1987). Therefore, USATHAMA allowed the following alternate purging and sampling protocol to be used where this difficulty is encountered:

- Purge the well dry a minimum of two times prior to sampling with a minimum of four hours between purging events;
- Calculate the volume of static water in the well casing and the saturated sand pack according to the Geotechnical Requirements;
- This calculated volume, as a minimum, must be evacuated from the well.

The reason for this protocol is to insure that formation water is sampled and not water that had been retained in the well or sand pack.

When a monitoring well is pumped down too low to sample, the sample shall be collected when the water level in such a well returns to 80 percent of the pre-pumping static water level. The volume of water purged will be measured by placing the purged

water in containers of known volume or by using a calibrated flow meter. Items to be recorded on the Groundwater Sampling Field Notes form and field notebook include:

- Depth to water before, during, and after purging
- Well purging method
- Total volume purged
- Time pump on and pump off
- Well volume calculations
- EC, pH, temperature, and turbidity
- Sounded depth of well
- Appearance of groundwater (color, turbidity, odor, etc.)
- Volume of standing water in well after well is pumped dry

3.2.6 Groundwater Sampling

Groundwater sampling will consist of two rounds of sampling and analyses of water from 17 existing wells and the 7 new replacement wells to be constructed at HAA. A recommended order of well sampling is presented in Table 3.2. The order of sampling is generally based on measured contamination levels; sites where contamination levels are expected to be lower will be sampled before those sites which are expected to have higher contamination levels based on historical monitoring results (Engineering Science 1991).

The recommended order of sampling may require modification during field sampling, since access to certain restricted sites may not be available when required.

Well construction details for the existing groundwater monitoring wells are summarized in Table 3.3. The table shows the screened interval, top of casing elevation, surface elevation, and groundwater elevation measured during Phase I investigation in 1990-91.

Groundwater sampling from the wells will be carried out by hand bailing. Standard environmental well sampling protocols and the additional specifications set forth in the USATHAMA Geotechnical Requirements will be followed.

Special USATHAMA requirements for sampling include triple-rinsing all sample containers with sample water, preservation of all water samples in the field and rinsing equipment only with water from a permitted source at Building 736 in the POL Area. After triple-rinsing and field preservation, the analytical sample should be collected from a freshly-filled bailer. Samples collected for metals analysis will be filtered using positive pressure filtration units with disposable vessels and 0.45 micron cellulose acetate filters.

3.3 FIELD QA/QC PROGRAM

Pertinent data collected during the investigation will be identified and reported to the project manager for validation.

TABLE 3.2
ORDER OF WELL SAMPLING
HAMILTON ARMY AIRFIELD EI/AA – Phase II

AREA	SAMPLING GROUP	MONITORING WELL ID
POL AREA	1	PL-MW-106
POL AREA		PL-MW-107
POL AREA		PL-MW-108
POL AREA		PL-MW-109
POL AREA		PL-MW-110
POL AREA		PL-MW-111A
POL AREA		PL-MW-111B
POL AREA		PL-MW-112A
POL AREA		PL-MW-112B
POL AREA		PL-MW-113A
POL AREA		PL-MW-113C
REVENTMENT	2	RV-MW-101, 102, 103
POL AREA		PL-MW-105
POL AREA		PL-MW-103
POL AREA		PL-MW-104
AIRCRAFT STORAGE AND MAINTENANCE AREA		AM-MW-101, 102, 103, 104
POL AREA		PL-MW-114, 115
POL AREA	3	PL-MW-101

Notes: Sampling order in each group may be modified based on field logistics.

Order of well sampling may be modified for Round 2 based on results of Round 1.

TABLE 3.3
PHASE I GROUNDWATER MONITORING WELL CONSTRUCTION DETAILS
HAMILTON ARMY AIRFIELD EI/AA - Phase I

AREA	MONITORING WELL ID	BOTTOM OF CASING (FEET)	SCREENED INTERVAL (FEET)	ELEVATION TOP OF PVC (FEET)	ELEVATION SURFACE (FEET)	DEPTH TO GROUNDWATER JAN/FEB 1991 (FEET)
POL AREA	PL-MW-101	49.8	29.8-49.3	49.44	47.1	28
	PL-MW-103	27	11.5-26.5	17.28	14.8	1
	PL-MW-104	42.8	27.8-42.3	27.29	24.8	18.8
	PL-MW-105	19.8	4.8-19.2	11.55	9.1	8.8
	PL-MW-106	18	7.8-17.3	6.59	4.4	5.7
	PL-MW-107	17.3	7.2-16.7	7.16	4.6	7.2
	PL-MW-108	17.2	7.1-16.6	6.87	4.5	7.1
	PL-MW-109	18.2	8.1-17.7	7.34	5.2	6.9
	PL-MW-110	17.1	6.9-16.5	19.94	17.5	7.3
	PL-MW-111A	17.45	7.3-16.8	7.35	5.2	3.1
	PL-MW-111B	29.5	24-29	7.68	5.2	3.9
	PL-MW-112A	17.05	7.4-16.9	4.2	1.7	8.1
	PL-MW-112B	29.8	24.7-29.2	4.21	1.8	1.5
	PL-MW-113A	16.9	6.7-16.2	4.99	2.6	5.9
	PL-MW-113C	30	24-29.5	5.41	2.8	3.5
REVETMENT AREA	RV-MW-101	25.5	5.3-24.9	-1.94	-4.4	6.7 (3/91)
AIRCRAFT STORAGE AND MAINTENANCE AREA	AM-MW-101	15.5	5-15	0.48	2	5.4 (12/90)

NOTE: All depths are feet below ground surface.

MWI

The following reporting units and standards will be used:

- pH will be reported to 0.1 pH units.
- Electric conductivity will be reported to two significant figures below 100 umhos/cm and three significant figures above 100 umhos/cm.
- Temperature will be reported to 0.5 degrees C.
- Turbidity will be reported to 0.1 NTUs.
- Water levels will be reported to the nearest 0.01 foot.
- The monitoring wells will have a permanently marked measuring point that will be surveyed to the nearest 0.01 foot and referenced to NGVD.
- Soil descriptions will be in accordance with the USCS.

Four types of field quality control (QC) samples will be collected during the two rounds of groundwater sampling, including: trip blanks, field duplicates, rinse blanks, and source water blanks. Information regarding collection of field QC samples will be recorded on the Groundwater Sampling Field Notes (Appendix A) and in the field logbook (Section 2.2).

The number, type, and composition of these QC samples is shown in Table 3.4 and discussed below:

- Trip blanks: A trip blank is a VOC sample container filled in the field with source water from Building 736 hose bib #1. The trip blank shall be transported to the site, handled like a field sample, and returned to the laboratory for analysis. One trip blank will accompany each shipment of groundwater samples sent to the analytical laboratory. The trip blanks shall be analyzed for VOCs.
- Field Duplicates: Field duplicates are two field samples collected independently at a groundwater monitoring well location during a single sampling of that well or two soil samples collected from adjacent locations. Both the duplicate and the corresponding sample shall generally be analyzed for the same parameters in the laboratory. Ten percent of samples shall be duplicates.

When collecting duplicate samples using a Modified California Sampler, the bottom sampling tube will be retained as the duplicate sample. The duplicate sediment sample will be collected from a location adjacent to the original sample. Duplicate slide hammer samples will be collected at the same location as the original sample but at a successive depth interval.

- Rinse Blanks: Rinse blanks are samples of collected and the final rinse water used in the decontamination process. Rinse blanks will be analyzed for the same parameters as the immediately proceeding samples.
- Source Water Blanks: Two samples of water used for decontamination from the Building 736 of the POL Area, hose bib #1 will be collected and analyzed for VOCs, SVOCs, TPH, and metals. One of the samples will also be analyzed for pesticides.

TABLE 3.4
SUMMARY OF QC ANALYTICAL PROGRAM
HAMILTON ARMY AIRFIELD EI/AA - Phase II

QC SAMPLE	MEDIUM	VOC	SVOC	TPH	BTEX	METALS	LEAD	PESTICIDES
FIELD DUPLICATES	Soil	2	2	10	8	5	4	1
	Water	5	1	5	4	1	4	0
	Sediment	1	1	1	0	1	0	0
RINSE BLANKS	Water	4	4	4	4	4	0	1
TRIP BLANKS	Water	8	0	0	0	0	0	0
SOURCE WATER BLANKS	Water	2	2	2	0	2	0	1

VOC - Volatile organic compounds

SVOC - Semi volatile organic compounds

TPH- Total petroleum hydrocarbon

BTEX - Benzene, toluene, ethylbenzene, xylene

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SECTION 4.0

FIELD INVESTIGATIONS

4.1 SOIL AND SEDIMENT INVESTIGATIONS AND ANALYTICAL PROGRAM

Site stratigraphy and the distribution of contaminants in soils at HAA will be evaluated with soil borings at the following areas:

- Background Locations
- POL Area
- Aircraft Storage and Maintenance Area
- Revetment Area
- Former Sewage Treatment Plant
- Building 442

Table 4.1 shows the drilling or sample collection method proposed for each of the areas, the number of sampling locations at each area, the sampling location designation, and the estimated total depth of the borings.

Table 4.2 is a summary of the soil/sediment sampling program. The table shows the proposed sample depths and analytical methods applicable for each sampling location. In addition to the chemical analyses specified for each of the six sites, two soil samples from each site will be analyzed for pH and one soil sample from each site will be analyzed for TOC. The purpose of the soil pH and TOC measurements is to obtain required information for Risk Assessment.

4.1.1 Background Areas

The Phase II investigations will include the taking of background soil samples at approximate depths of 0, 2, and 4 feet, from five soil borings around the perimeter of the site. The borings will be completed by hand auger and samples analyzed for metals. The approximate locations of the borings are shown on Figure 4.1.

4.1.2 POL Area

The Phase II work at the POL Area is designed to investigate the extent and type of soil and groundwater contamination in the vicinity of the former AST-2 location and near the associated fuel line and fuel pumps. Two samples will be obtained from each of 16

TABLE 4.1
SOIL/SEDIMENT BORING PROGRAM
HAMILTON ARMY AIRFIELD EI/AA - Phase II

AREA	SAMPLE METHOD	MEDIUM	NUMBER OF SAMPLING SITES	SAMPLING SITE DESIGNATION	ESTIMATED TOTAL DEPTH (FEET)
POL AREA	Drill Rig Boring	Soil	16	PL-SB-1 to PL-SB-16	20 (or refusal)
AIRCRAFT STORAGE AND MAINTENANCE AREA	Drill Rig Boring Shovel Sample	Soil Sediment	10 8	AM-SB-1 to AM-SB-10 AM-SD-4 to AM-SD-11	5 0
REVETMENT AREA	Drill Rig Boring	Soil	16	RV-SB-1 to RV-SB-16	5
FORMER SEWAGE TREATMENT PLANT	Slide Hammer/Hand Auger	Soil	8	TP-SS-1 to TP-SS-8	1 to 2 (In Native Soil)
BUILDING 442	Slide Hammer/Hand Auger	Soil	3	BL-SS-1 to BL-SS-3	2 to 3
BACKGROUND	Slide Hammer/Hand Auger	Soil	5	BK-SS-3 to BK-SS-7	5

mmw10

TABLE 4.2
SOIL/SEDIMENT SAMPLING PROGRAM SUMMARY
HAMILTON ARMY AIRFIELD EI/AA - Phase II

AREA	SAMPLING SITE DESIGNATION	SAMPLE DEPTH (FEET)	ANALYTES
POL AREA	PL-SB-1 to PL-SB-16	A	TPH,BTEX,(pH at 2 sites, TOC at 1 site)
	PL-MW-114	B	TPH,VOCs,Lead
	PL-MW-115	B	TPH,VOCs,Lead
AIRCRAFT STORAGE AND MAINTENANCE AREA	AM-SB-1 to AM-SB-10	2	TPH,METALS
	AM-SB-1 to AM-SB-10	4	METALS
	AM-MW-102	B	TPH,VOCs,SVOCs,Metals
	AM-MW-103	B	TPH,VOCs,SVOCs,Metals,pH
	AM-MW-104	B	TPH,VOCs,SVOCs,Metals,pH,TOC
	AM-SD-4 to AM-SD-11	0	TPH,VOCs,SVOCs,Metals
REVETMENT AREA	RV-SB-1 to RV-SB-16	2	TPH,BTEX,Lead
	RV-SB-1 to RV-SB-16	4	TPH,BTEX,Lead
	RV-MW-102	B	TPH,BTEX,Lead,pH
	RV-MW-103	B	TPH,BTEX,Lead,pH,TOC
SEWAGE TREATMENT PLANT	TP-SS-1 to TP-SS-6	1-2	TPH,VOCs,SVOCs,Metals,Pesticides
	TP-SS-7	1-2	TPH,VOCs,SVOCs,Metals,Pesticides,pH
	TP-SS-8	1-2	TPH,VOCs,SVOCs,Metals,Pesticides,pH,TOC
BUILDING 442	BL-SS-1	2-3	TPH,BTEX,Lead
	BL-SS-2	2-3	TPH,BTEX,Lead,pH
	BL-SS-3	2-3	TPH,BTEX,Lead,pH,TOC
BACKGROUND	BK-SS-3 to BK-SS-7	0	Metals
	BK-SS-3 to BK-SS-6	2	Metals
	BK-SS-3 to BK-SS-6	5	Metals
	BK-SS-7	2	Metals,pH
	BK-SS-7	5	Metals,pH,TOC

NOTES: A-Two samples; one above water table,
one with highest PID reading.

B-One sample above water table.

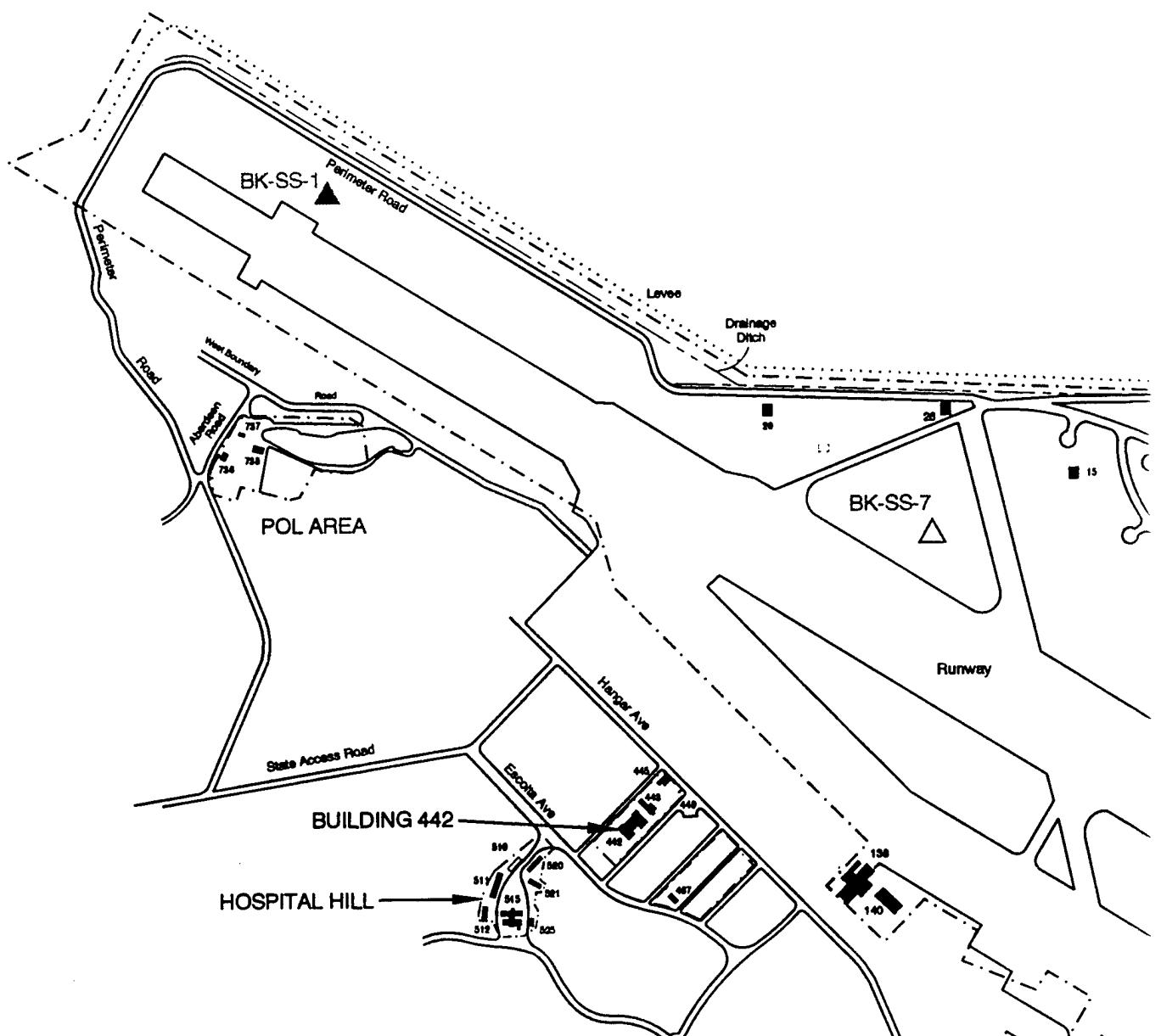
VOC - Volatile organic compounds

SVOC - Semi volatile organic compounds

TPH- Total petroleum hydrocarbons

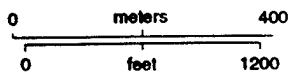
BTEX - Benzene, toluene, ethylbenzene, xylene

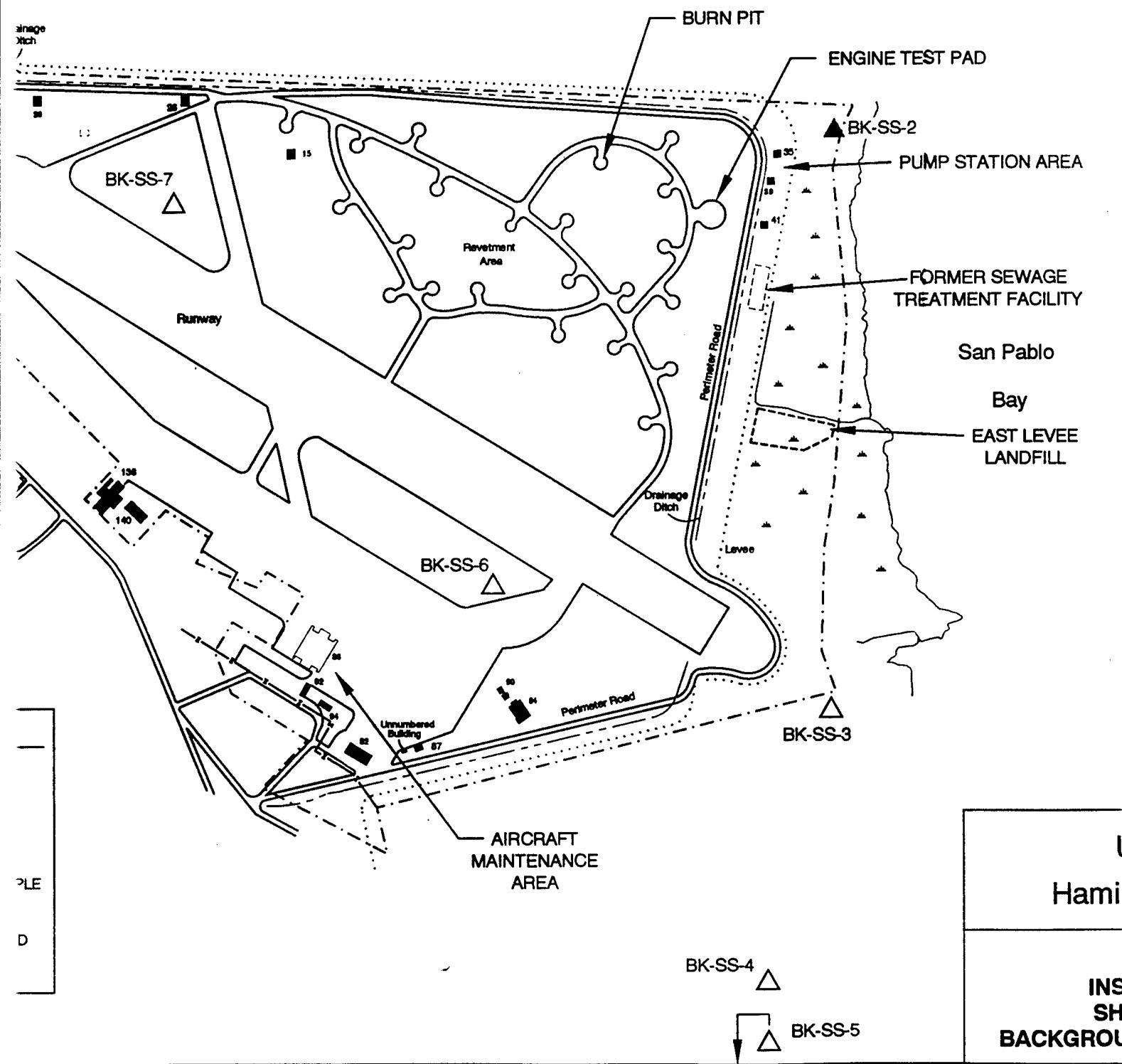
TOC - Total organic carbon

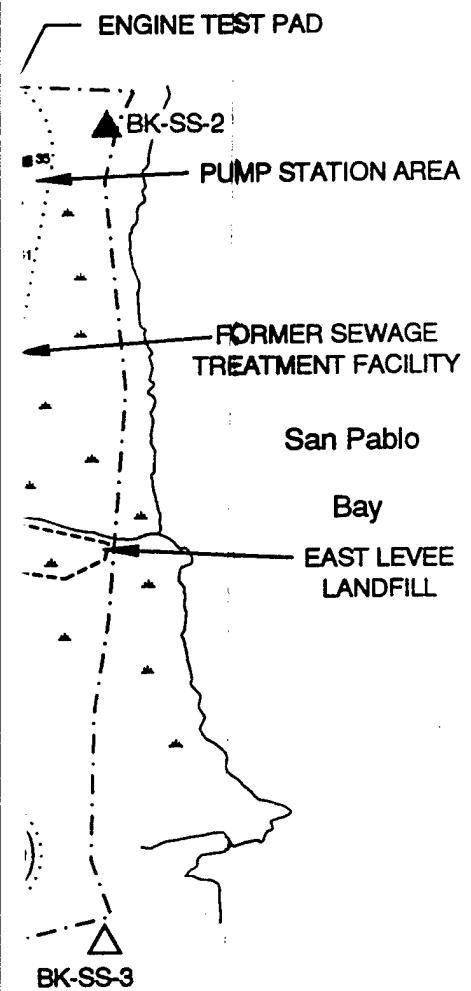


LEGEND

- ... - - - STUDY AREA BOUNDARY
- LEVEE CREST
- - - DRAINAGE DITCH
- ▲ BACKGROUND SOIL SAMPLE LOCATION-PHASE I
- △ PROPOSED BACKGROUND SOIL SAMPLE LOCATION-PHASE II







USATHAMA
Hamilton Army Airfield

FIGURE 4.1
INSTALLATION MAP
SHOWING PHASE 2
BACKGROUND SAMPLE LOCATIONS

BK-SS-5

ENGINEERING-SCIENCE

drill rig borings and analyzed for TPH and BTEX. The approximate locations of the borings are shown on Figure 4.2. The auger boring locations may be modified in the field so as not to be located near shallow bedrock where the auger may be ineffective.

Borings will be drilled to the top of the water table or to refusal and sampled at approximately 2 1/2 foot intervals using a split spoon sampler. Based on results of Phase I water level measurements, depth to the water table at the proposed boring locations should generally be approximately 8 feet.

Two samples will be retained for laboratory analyses from each boring. The first sample will be the one obtained immediately above the water table. The second will be the sample (not including the water table sample) with the highest PID value. If no contamination is detected with the PID, the field geologist will select the second sample at a depth of approximately 1/2 the first sample depth.

In addition, one cuttings sample will be collected from each of the two air rotary borings to be converted to monitoring wells. Sample depths will be selected based on PID headspace readings from the cuttings. The planned analyses are VOC, TPH, and lead.

4.1.3 Aircraft Maintenance and Storage Area

Phase II work at the Aircraft Storage and Maintenance Area is designed to further evaluate soil and groundwater contamination. Two samples will be obtained from each of 10 drill rig borings and analyzed for metals and TPH. Samples will be obtained from depths of approximately 2 and 4 feet. A single split spoon soil sample will also be obtained from above the water table in each of the three new monitoring well borings and analyzed for VOCs, SVOCs, and TPH. Sediment samples will be obtained from eight storm drain locations and analyzed for VOCs, SVOCs, metals, and TPH. The approximate locations of the borings are shown on Figure 4.3.

4.1.4 Revetment Area

Phase II investigations at the Revetment Area are designed to further evaluate the extent of contamination discovered during the Phase I investigation. Four borings will be completed by drill rig around pads #17, 20, 26, and 27. The approximate locations of the borings are shown on Figure 4.4. Two samples will be obtained from each of 16 borings and analyzed for TPH, BTEX, and lead. Samples will be obtained from depths of approximately 2 and 4 feet. One split spoon soil sample will be obtained from above the water table in each of the two new monitoring well borings and analyzed for TPH, BTEX, and lead.

4.1.5 Former Sewage Treatment Plant

Phase II investigations at the Former Sewage Treatment Plant will be completed to evaluate remediation efforts at the sludge drying beds. Eight borings, two from each drying bed will be hand augered. The approximate locations of the borings are shown on Figure 4.5. A single sample will be obtained at a depth of 2 to 3 feet from each boring and analyzed for VOCs, SVOCs, metals, TPH, and pesticides.

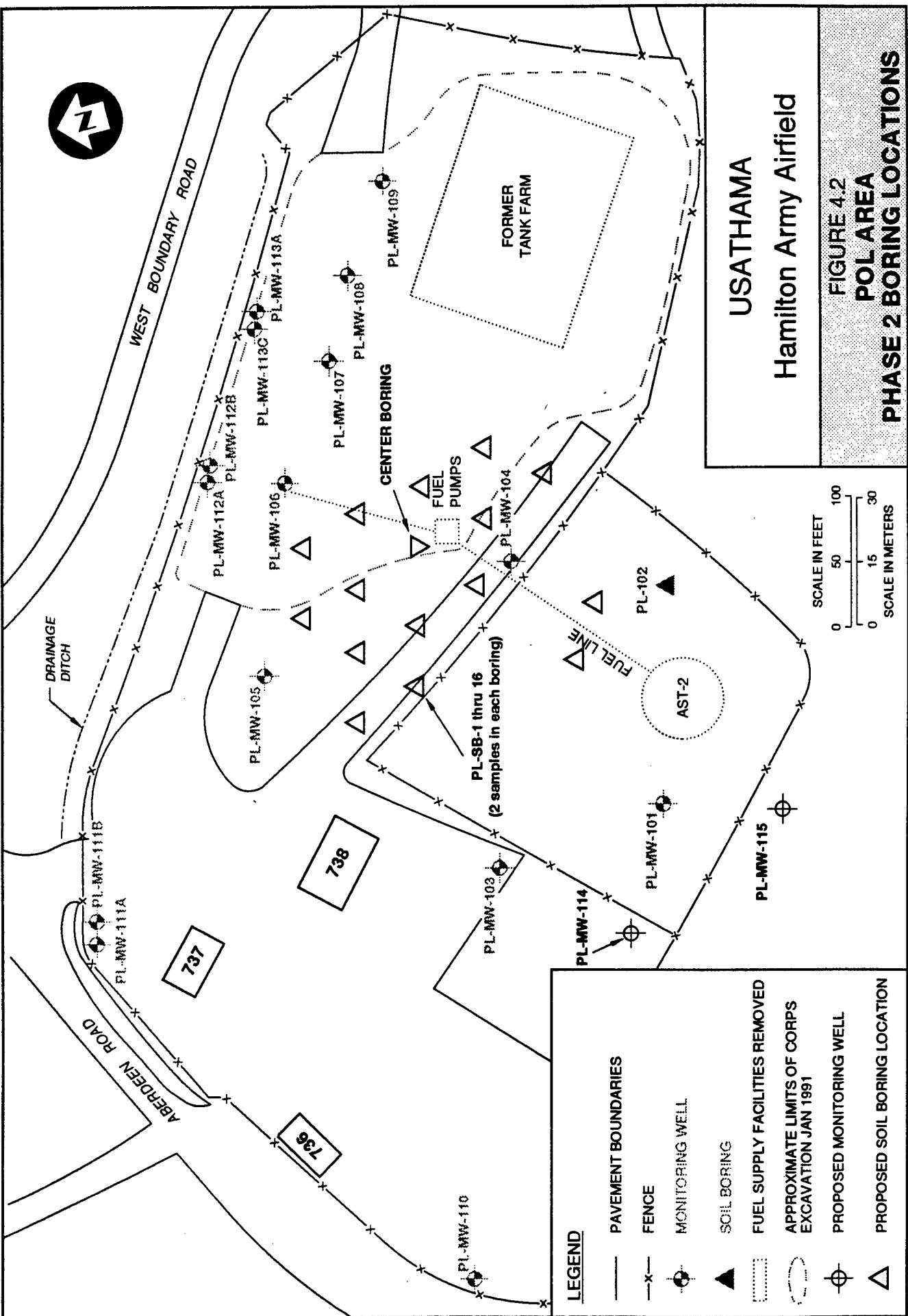


FIGURE 4.2
POL AREA
PHASE 2 BORING LOCATIONS

ENGINEERING-SCIENCE

G77-116 07/09/92

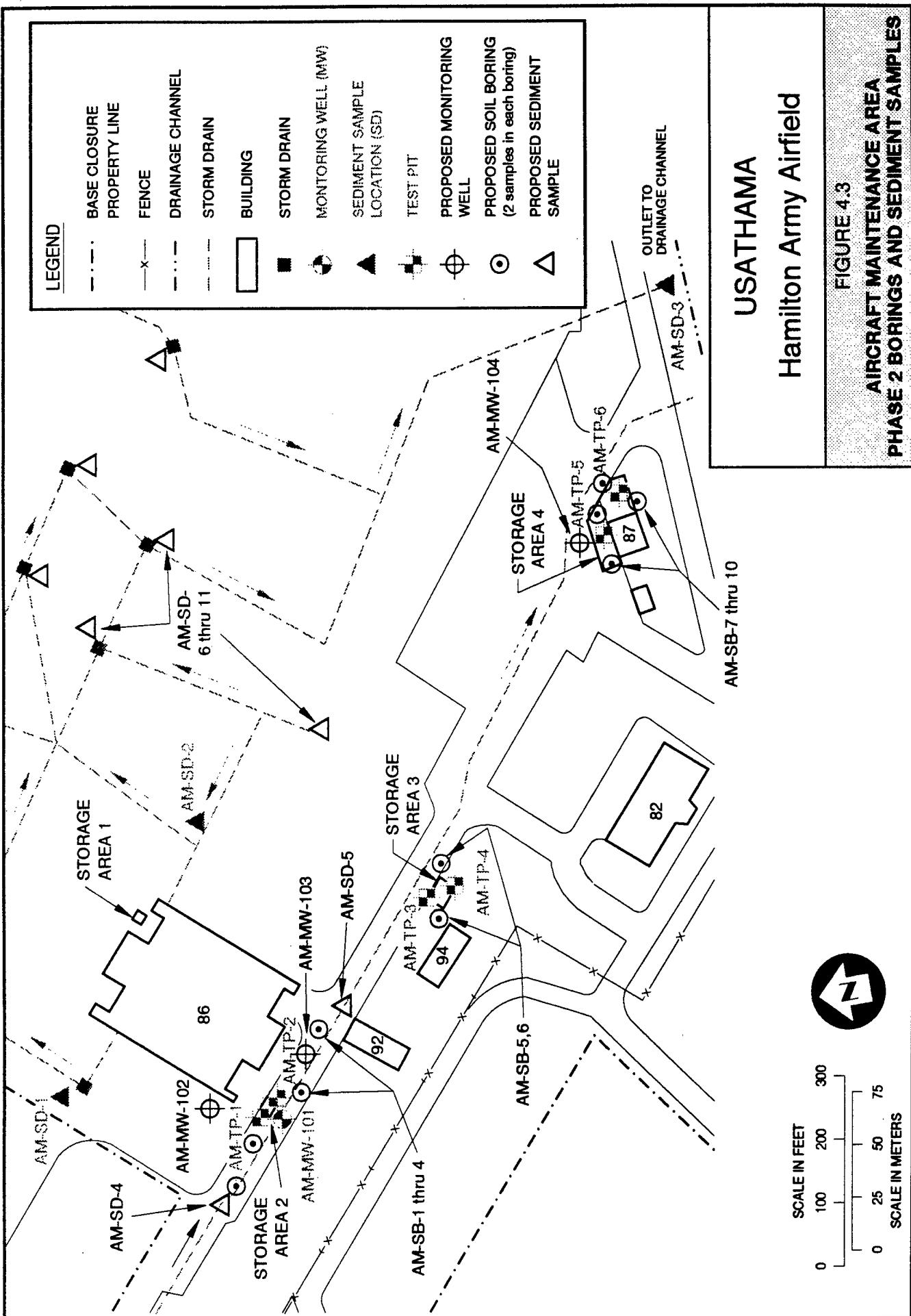
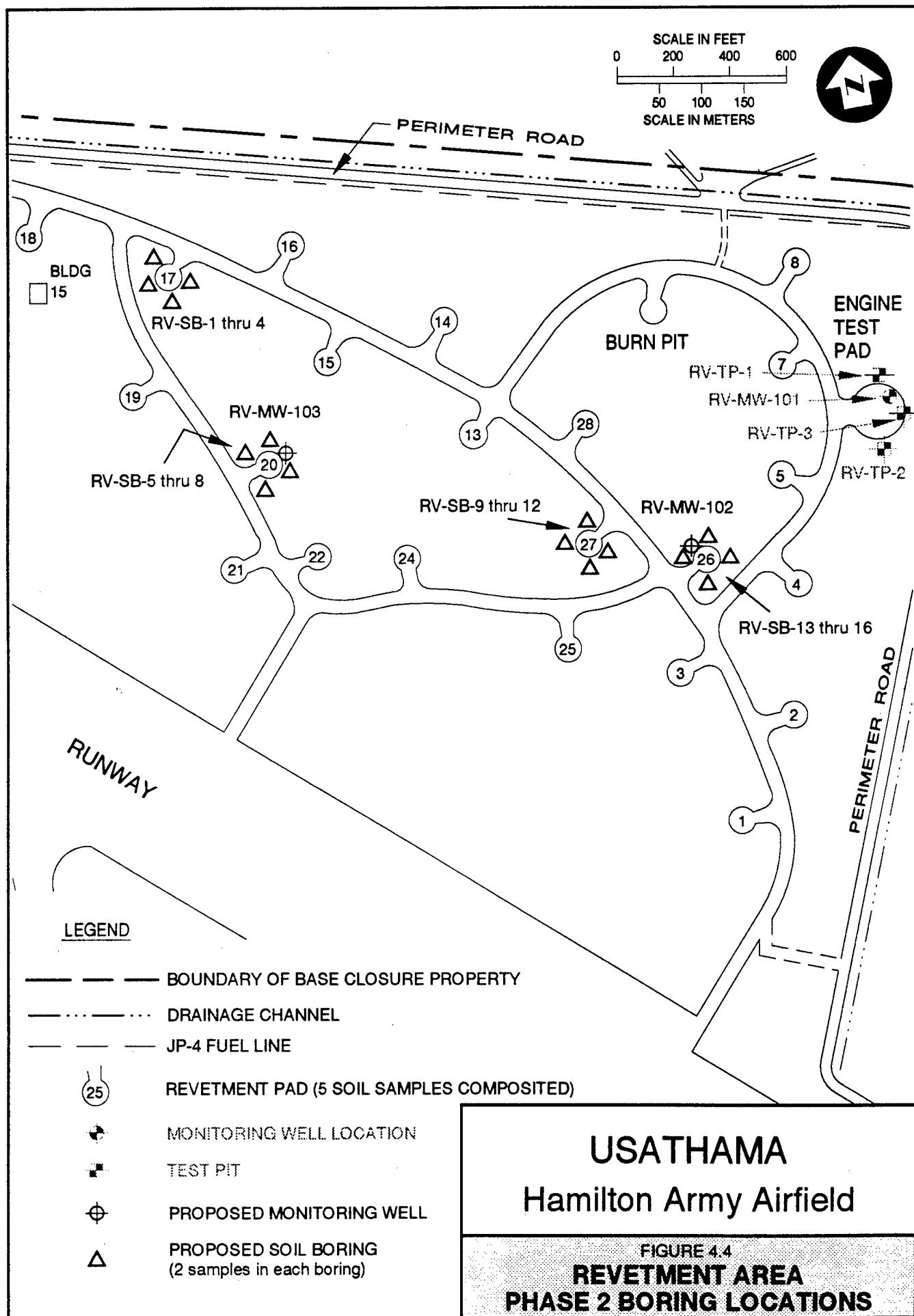
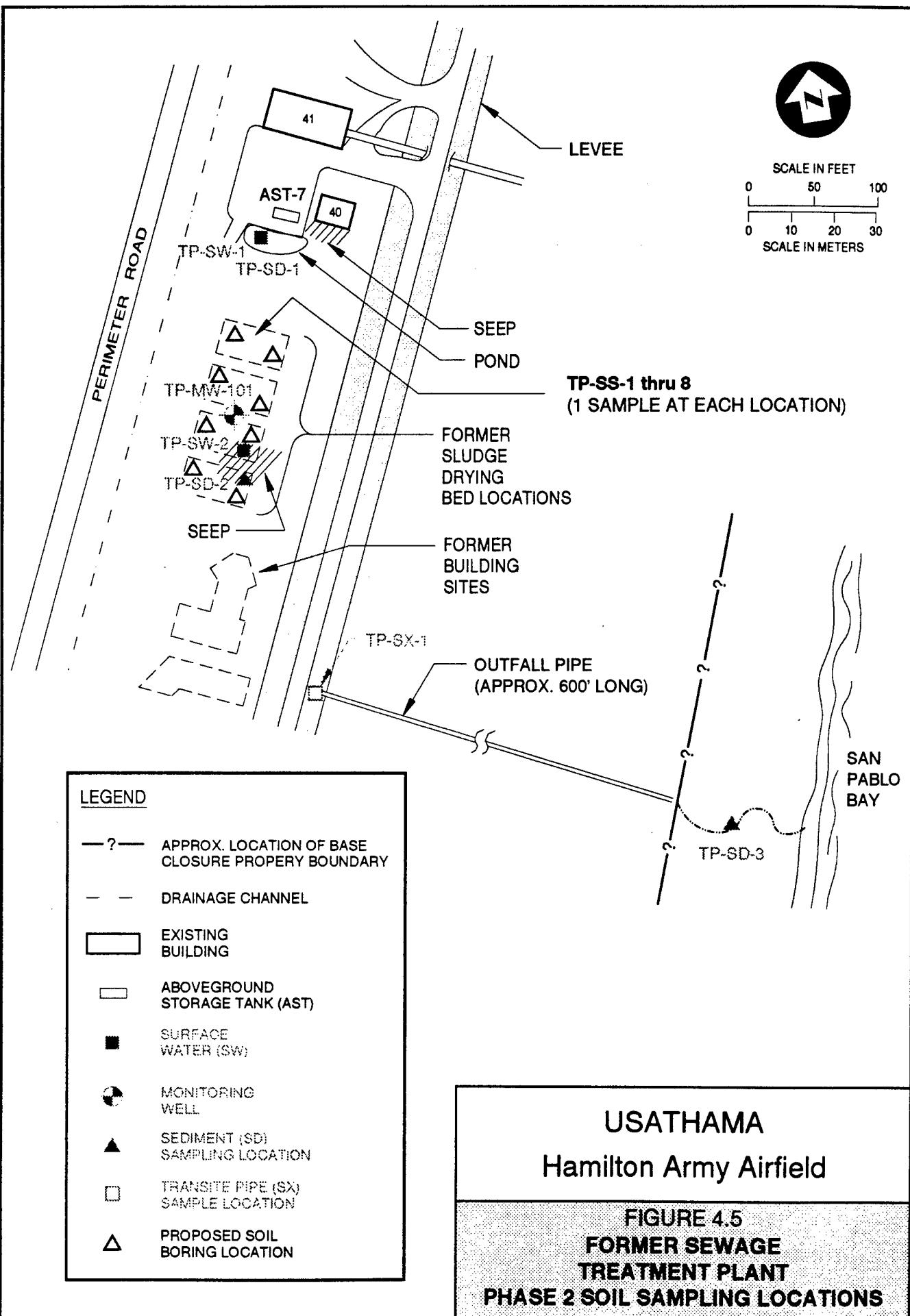


FIGURE 4.3
AIRCRAFT MAINTENANCE AREA
PHASE 2 BORINGS AND SEDIMENT SAMPLES

ENGINEERING-SCIENCE





4.1.6 Building 442

Phase II investigations at the Building 442 site will be completed to confirm previous soil gas surveys and determine if contamination has occurred in the vicinity of AST-11 and the adjacent underground utility trench. Three shallow borings will be hand augered and sampled at a depth of approximately 2 to 3 feet for TPH, BTEX, and lead. The approximate locations of the borings are shown on Figure 4.6.

4.2 GROUNDWATER INVESTIGATIONS

Groundwater monitoring wells will be drilled and installed by a California licensed drilling contractor. Two monitoring wells will be drilled in the POL Area, three in the Aircraft Maintenance and Storage Area, and two in the Revetment Area. The proposed locations of the wells are shown on Figures 4.2, 4.3, and 4.4.

Tables 4.3 and 4.4 show the groundwater sampling program for the Round 1 and Round 2 sampling programs, respectively. The tables show the analytical methods required at each of the monitoring wells and the locations where duplicate samples are to be collected. The tables also show the order in which sample bottles are to be filled. Sample bottles will be filled in order of volatilization. Both Round 1 and Round 2 samplings are scheduled for August 1992.

4.2.1 POL Area

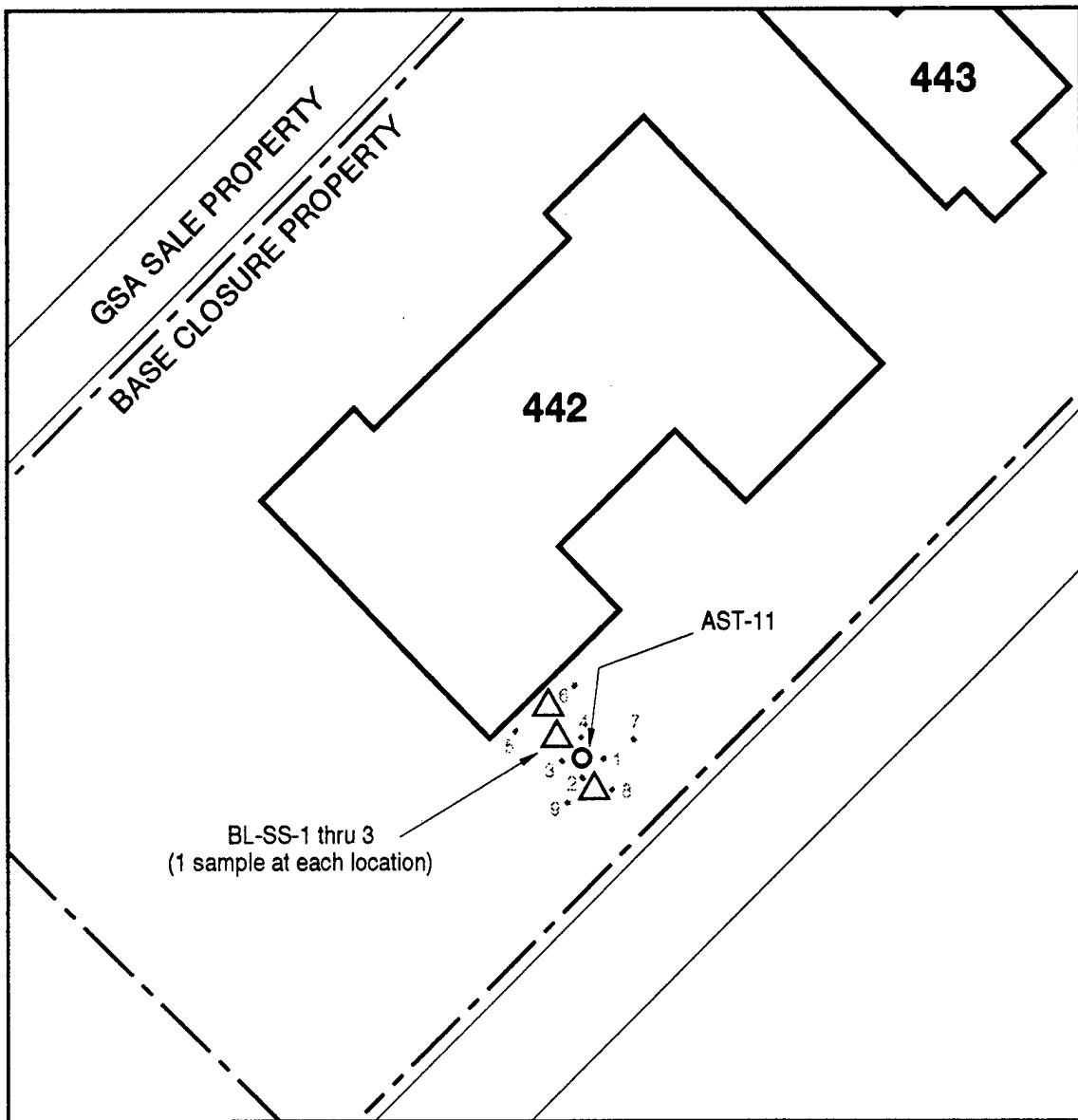
Groundwater analyses in the POL Area for both sampling rounds include BTEX, TPH, and lead. Samples will also be collected from all wells for TDS analysis during the first sampling round only.

4.2.2 Aircraft Storage and Maintenance Area

Groundwater analyses in the Aircraft Storage and Maintenance Area for both rounds of sampling includes VOCs, SVOCs, TPH, and metals. Samples will also be collected from all wells for TDS analysis during the first sampling round only.

4.2.3 Revetment Area

Groundwater analyses in the Revetment Area for both rounds of sampling include BTEX, TPH, and lead. Samples will also be collected from all wells for TDS analyses during the first sampling round only.



USATHAMA
Hamilton Army Airfield

SCALE IN FEET
0 50 100

0 10 20 30

SCALE IN METERS

FIGURE 4.6
BUILDING 442
PHASE 2 SOIL SAMPLING LOCATIONS

TABLE 4.3
GROUNDWATER SAMPLING ANALYTICAL PROGRAM - ROUND 1
HAMILTON ARMY AIRFIELD EI/AA - Phase II

AREA	MONITORING WELL ID	VOCS (1)	TPH (2)	SVOCs (3)	BTEX (4)	LEAD (5)	METALS (6)	TDS (6)
POL AREA	PL-MW-101		D		D	D		X
	PL-MW-103		X		X	X		X
	PL-MW-104		X		X	X		X
	PL-MW-105		X		X	X		X
	PL-MW-106		X		X	X		X
	PL-MW-107		X		X	X		X
	PL-MW-108		X		X	X		X
	PL-MW-109		X		X	X		X
	PL-MW-110		X		X	X		X
	PL-MW-111A		X		X	X		X
	PL-MW-111B		X		X	X		X
	PL-MW-112A		X		X	X		X
	PL-MW-112B		X		X	X		X
	PL-MW-113A		X		X	X		X
	PL-MW-113C		X		X	X		X
	PL-MW-114		X		X	X		X
	PL-MW-115		D		D	D		X
AIRCRAFT STORAGE AND MAINTENANCE AREA	AM-MW-101	X	X	X			D	X
	AM-MW-102	X	X	X			X	X
	AM-MW-103	X	X	X			X	X
	AM-MW-104	X	X	X			X	X
REVETMENT AREA	RV-MW-101		D		D	D		X
	RV-MW-102		X		X	X		X
	RV-MW-103		X		X	X		X

NOTE: This table does not include quality control samples.

D - Duplicate sampling location.

(1) - Indicates order to fill sample bottles.

VOC - Volatile organic compounds

SVOC - Semi volatile organic compounds

TPH- Total Petroleum hydrocarbon

BTEX - Benzene, toluene, ethylbenzene, xylene

TDS - Total dissolved solids

TABLE 4.4
GROUNDWATER SAMPLING ANALYTICAL PROGRAM - ROUND 2
HAMILTON ARMY AIRFIELD EI/AA - Phase II

AREA	MONITORING WELL ID	VOCS (1)	BTEX (2)	SVOCs (3)	TPH (4)	LEAD (5)	METALS (6)
POL AREA	PL-MW-101		X		X	X	
	PL-MW-103		X		X	X	
	PL-MW-104		D		D	D	
	PL-MW-105		X		X	X	
	PL-MW-106		X		X	X	
	PL-MW-107		X		X	X	
	PL-MW-108		X		X	X	
	PL-MW-109		X		X	X	
	PL-MW-110		X		X	X	
	PL-MW-111A		X		X	X	
	PL-MW-111B		X		X	X	
	PL-MW-112A		X		X	X	
	PL-MW-112B		X		X	X	
	PL-MW-113A		X		X	X	
	PL-MW-113C		X		X	X	
	PL-MW-114		X		X	X	
	PL-MW-115		X		X	X	
AIRCRAFT STORAGE AND MAINTENANCE AREA	AM-MW-101	X		X	X		X
	AM-MW-102	X		X	X		X
	AM-MW-103	X		X	X		X
	AM-MW-104	X		X	X		X
REVETMENT AREA	RV-MW-101		X		X	X	
	RV-MW-102		D		D	D	
	RV-MW-103		X		X	X	

NOTE: This table does not include quality control samples.

D - Duplicate sampling location.

(1) - Indicates order to fill sample bottles.

VOC - Volatile organic compounds

SVOC - Semi volatile organic compounds

TPH- Total Petroleum hydrocarbon

BTEX - Benzene, toluene, ethylbenzene, xylene

SECTION 5.0

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APPENDIX A

PROJECT FORMS

LABORATORY: DATA CHEM

CHAIN OF CUSTODY

CLIENT:	PROJECT MANAGER:	PROJ
ENGINEERING-SCIENCE, INC. ALAMEDA, CALIFORNIA	FRED KINTZER	NC

PROJECT NAME / LOCATION:

HAWAII TON ARMY AIRFIELD

SAMPLER(S): (SIGNATURE)

SAMPLE ID	SITE ID	SITE TYPE ¹	DATE	TIME	SAMPLE DEPTH	MATRIX
						SOIL

卷之三

(SIGNATURE)

DISTRIBUTION: ORIGINAL ACCOMPANIES SHIPMENTS; COPY TO COORDINATOR FIELD FILES

LABORATORY; DATA CHEM

CHAIN OF CUSTODY

DISTRIBUTION: ORIGINAL ACCOMPANIES SHIPMENTS; COPY TO COORDINATOR FIELD FILES

LABORATORY: DATA SHEET

CHAIN OF CUSTODY

CLIENT:	PROJECT MANAGER:	PROJ. NO.
ENGINEERING-SCIENCE, INC. ALAMEDA, CALIFORNIA	FRED KINTZER	NC282

PROJECT NAME / LOCATION:

HAWAIIAN ABILITY INDEX

SAMPI FB(S) · (SIGNATURE)

SAMPLE ID	SITE ID	SITE TYPE	DATE	TIME	SAMPLE DEPTH*	MATRIX	SEDIMENT
	STSW						

ANSWER

ANSWER

TABLE OF CONTENTS

ANSWER

1000

ANSWER

ANSWER

1000

1000

ANSWER

REINQUISITION BY: (SIGNATURE) _____ DATE/TIME _____ RECEIVED BY: (SIGNATURE) _____

1000

RECEIVED FOR LABOUR
(SIGNATURE)
DAVID IMPEY

DISTRIBUTION: ORIGINAL ACCOMPANIES SHIPMENTS; COPY TO COORDINATOR END EC

C194-22.500 07/30/2022

DISTRIBUTION: ORIGINAL ACCOMPANIES SHIPMENTS; COPY TO COORDINATOR END EC

BORING LOG				BORING NO.
				SITE I.D. NO.
PROJECT NO. NC282	PROJECT NAME: HAMILTON ARMY AIRFIELD E/AA PHASE II			PAGE OF
CONTRACTOR: GUESS DRILLING	DRILLER		DATE STARTED	COMPLETED
METHOD	CASING SIZE 4" I.D.		PID	PROTECT'N LEVEL D
GROUND EL.	SOIL DEPTH		— BELOW GRND	TOTAL DEPTH
LOGGED BY	CH'D BY		DATE	SCREENED INTERVAL

BACKGROUND PID LEVEL:

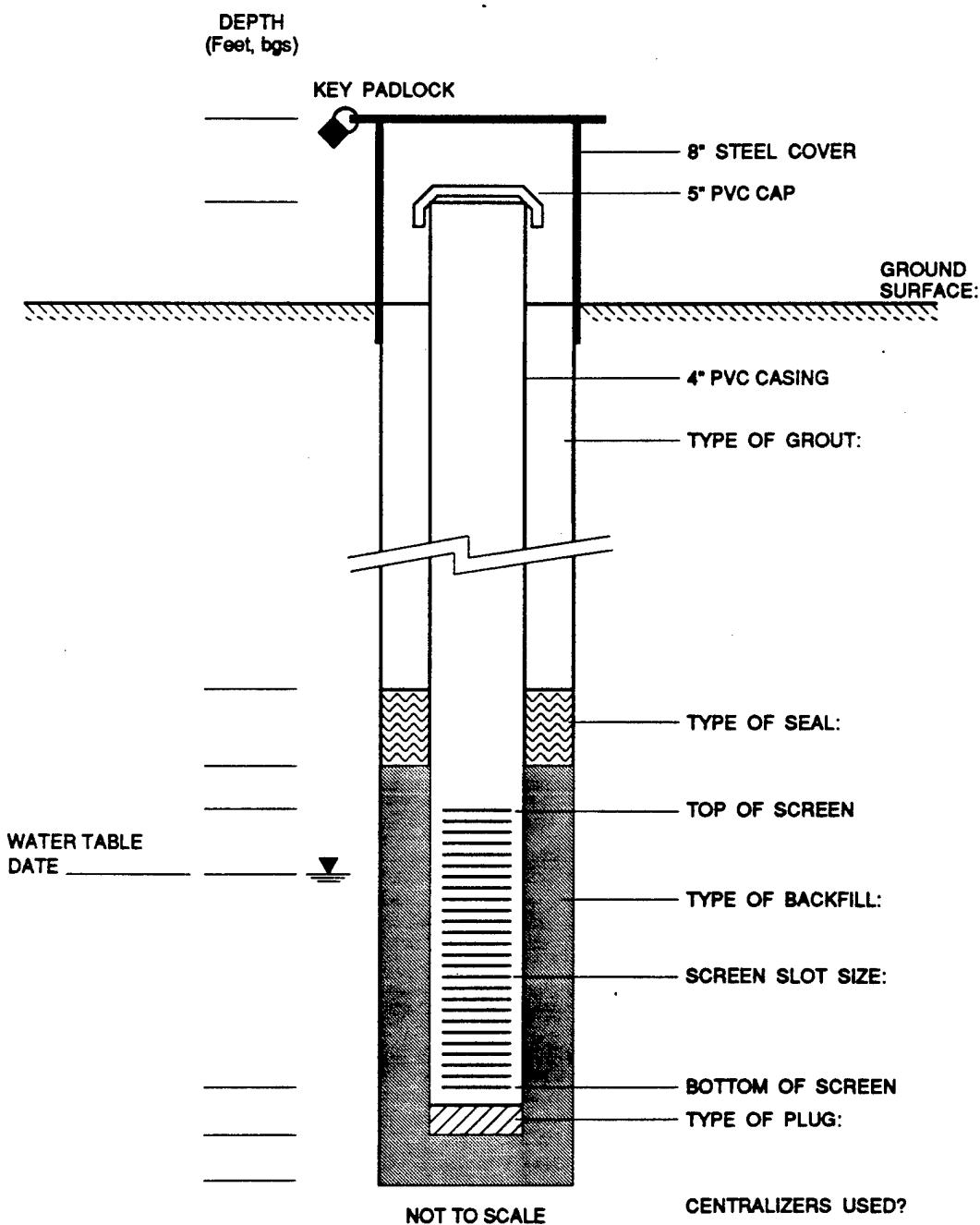
HAMMER WEIGHT:

HAMMER DROP:

SAMPLE NO.	DEPTH IN FEET	BLOWS PER 6 IN.	PEN/REC.	PID S.SPOON (ppm)	SOIL DESCRIPTION AND COMMENTS ON ADVANCE OF BORING (INCLUDES WATER LOSS AND MAJOR STRATA CHANGES)	USCS

MONITORING WELL INSTALLATION DATA RECORD

PROJECT NAME:	HAMILTON EI / AA PHASE II	BORING DIAMETER:	WELL NO:
PROJECT NO:	NC282	WELL INSIDE DIAMETER: 4"	SITE I.D. NO.:
DRILLING CO:	GUESS DRILLING	WELL MATERIAL: PVC	DATE INSTALLED:
FIELD SCIENTIST:		TOP OF PVC ELEVATION:	DRILLING METHOD:
		GS ELEVATION:	DEVELOPMENT METHOD:



WELL DEVELOPMENT

Job #

Job Name: _____

Developer(s) _____ Date: _____

Date: _____

BH#: _____ Pump Level: Depth _____ Time _____ :Depth _____ Time _____ :Depth _____ Time: _____

Depth to ground water below top of casing at beginning of test _____

Distance from top of well cover to top of casing _____

Depth to bottom of well from top of casing(depth to silt) .

AIR MONITORING DATA

SUBMIT COPIES OF THIS FORM TO THE HEALTH & SAFETY OFFICE AND THE PROJECT FILE

05/21/91
601-44.wk1/all

GROUNDWATER SAMPLING FIELD NOTES

* WATER LEVEL FROM GROUND SURFACE

**DAILY TRIP REPORT
FOR EQUIPMENT AND SUPPLY USE**

Project Number NC 282.02.20 (Field Activities) Date _____
 Project Manager F. Kintzer
 Project Name Hamilton Army Airfield EVA
Phase II

Purpose of Trip _____

ES Personnel _____

If trip was for more than one project, indicate percentage of use to be charged to each.

Transportation (Specify if special use, truck, van or 4x4)

Personal Vehicle

ES Vehicle Make/License No. _____

Time _____

Mileage _____

Rental Vehicle

License No. _____

Time _____

Rental Agency _____

Mileage _____

Commercial

Air

Taxi/Limo

Rail

Safety Equipment (Specify type or number used)

PID _____

Sensidyne Pump _____

Sensidyne Tubes _____

A/P Respirator _____

Respirator Cartridges _____

Field Equipment (Specify I.D. or Serial No. if applicable)

Tank Trailer _____

Hand Auger _____

Bailey _____

PVC _____

Teflon _____

Transit/Level _____

Pump (type) _____

Conductivity Meter _____

pH/Temperature Meter _____

Water Level Indicator _____

Water Oil Interface Probe _____

Camera _____

Tool Box _____

Other _____

Expendable Materials (No. Used)

Locks _____

Tyveks _____

Gloves _____

Surgical _____

Neoprene _____

Other _____

Filters _____

Jars _____

40ml VOA _____

100ml _____

500ml _____

1000ml _____

1 qt mason _____

Brass tubes _____

Decon Chemicals (type & amount) _____

No. of Samples Collected Types of Analyses

_____ _____

_____ _____

_____ _____

_____ _____

DAILY FIELD REPORT

JOB NAME	<u>Hamilton Army Airfield</u>
PROJECT	<u>E1/AA Phase II</u>
JOB NO.	<u>NC 282.02.20 (Field)</u>
LOCATION	<u>Novato, CA</u>
CLIENT	<u>USA THAI AIA</u>

DATE _____
REPORT NO. _____
SHEET _____ OF _____
WEATHER _____
TEMP _____ AT _____ AM/PM

WORK IN PROGRESS OR COMPLETE: (INCLUDING SUBCONTRACTORS)

VERBAL DISCUSSIONS/INSTRUCTIONS

REQUESTS FOR PROJECT ACTION

VISITORS

ACCIDENTS REPORTED TODAY
ACCIDENTS TO DATE

E-S REPRESENTATIVE

CS-109 11/88

CLIENT REPRESENTATIVE

APPENDIX B

INSTRUMENTATION SPECIFICATIONS AND CALIBRATION PROCEDURES

**PHOTOIONIZATION DETECTOR
(Photovac Microtip)**

PHOTOVAC MICROTIP PHOTOIONIZATION DEVICE (PID)

USE AND MAINTENANCE

DESCRIPTION

The MICROTIP, manufactured by Photovac, Inc., is a photoionization device (PID). This is a microprocessor controlled instrument which measures the concentration of airborne ionizable gases and vapors and automatically displays and records these concentrations. Gases and vapors are displayed and recorded in terms of parts per million (ppm) of total ionizable vapors. The MICROTIP can be calibrated to be more sensitive to a particular gas, but the reading will still be in terms of total ionizable gases. Details about PID use in general are available in the Engineering-Science Health and Safety Training Manual for Hazardous Waste Operations.

The microprocessor in the MICROTIP controls the components of the instrument and interprets and records the signal generated by the PID. Recorded data and setup information entered into the microprocessor's memory are retained when the MICROTIP is turned off.

When turned on, a pump continuously pulls the test air through the PID. The PID converts the concentration of ionizable chemicals in the sample into an electrical signal. The microprocessor subtracts any background from the signal and multiplies that signal by a response factor previously obtained by calibrating with a standard gas of known concentration. This concentration appears on the display and, depending on the values entered through the keypad, an alarm message may be heard.

When using this instrument, the number of hours of use per day should be recorded on the Daily Trip Report form.

MAINTENANCE

Battery Charging

The Engineering-Science Berkeley Office Hazardous Waste Management Department has two batteries for the MICROTIP. Each battery is rated by the manufacturer for four hours of continual use. While this four hours should be considered the maximum usable time for each battery for planning

purposes, recent field experience indicates that five or six hours of use may be obtained per battery recharge.

When the display reads "LoBat", the battery requires recharging. Use of the instrument after the "LoBat" indication may result in false readings. If one is available, simply replace the discharged battery with a fresh one.

To recharge a battery pack, plug the charger into the battery (make sure the charger is set to the proper AC line voltage) then plug the charger into an AC outlet. The charger automatically charges at a high charge rate until the battery is fully charged (at least eight hours) and then maintains the full charge with a low continuous charge rate indefinitely so there is no danger of overcharging. The battery does not need to be fully discharged before recharging.

Replacing the Filter Cartridge

The MICROTIP is equipped with a dust filter to reduce detector contamination. As the filter collects dust, the inlet flow rate and sensitivity will decrease. The filter should be replaced every 240 hours or more frequently if used in a dusty environment. This procedure is best done in the office either before or after the job. A supply of filters is in the instrument case, with additional filters available from the office equipment manager. To replace the filter:

1. Turn the instrument off.
2. Hold the filter housing near the detector housing with a 9/16" wrench.
3. Unscrew the top of the filter housing with another 9/16" wrench. Be careful not to lose the metal sealing washer.
4. Remove the spring and filter and install the new filter, open end first. The filters are small, cylindrical (approximately 1/4" diameter) and grey metallic colored.
5. Replace the filter spring and the filter housing. Tighten the top nut while holding the bottom one stationary with the wrench.
6. Once recalibrated, the instrument is ready for use.

Lamp Window Cleaning

During the course of normal operation a film builds up on the window of the detector ultraviolet lamp. The rate at

which the film develops depends on the type and concentration of the gases and vapors being sampled and results from the ultraviolet light interacting with them. As a guide, clean the window every 24 hours of operation. To clean the lamp window:

1. Turn the instrument off.
2. Remove the detector housing, being careful not to lose the O-ring seal on top of the detector. The detector cell, lamp holder, and UHF driver circuit board are now exposed.
3. Unplug the red and yellow wires from the UHF driver circuit board. Be sure to remember the positions of the wires for reattachment.
4. Hold the lamp holder in one hand so it will not rotate and carefully unscrew the detector cell with the red and yellow wires attached. DO NOT touch the fine wire mesh inside the detector cell.
5. Leaving the lamp spring in place, remove the lamp from the lamp holder.
6. To remove the film, gently rub the window of the lamp with a lint free tissue moistened with methanol.
7. Allow the window to dry and then, without touching the window, replace the lamp in the lamp holder.
8. Replace the detector cell squarely on the lamp holder and ensure the O-ring seal is in position. Finger tighten only.
9. Plug the yellow wire onto the gold pin and the red wire onto the silver pin on the UHV dirver circuit board.
10. Replace the detector housing and tighten by hand.
11. Once calibrated, the MICROTIP is ready for operation.

Other User Maintenance

Other user maintenance includes the replacement of the UV detector lamp (should the lamp burn out or if a different power rating is desired), and replacement of the air pump (the pump should be replaced after every 5,000 hours of operation). See the instruction manual for details of these operations.

MICROTIP USE

Use of the MICROTIP consists of four steps:

1. Initial Startup
2. Calibration
3. Setup and Use
4. Data Retrieval (if desired)

1. Initial Startup

After installing a fresh battery pack, turn on the MICROTIP. The air pump will start and the display will read "Warming Up Now, Please Wait..". Within three minutes the following information will appear on the display: Instrument status, detected concentration, event number, time, and date. The MICROTIP should next be calibrated.

2. Calibration

The MICROTIP must be calibrated in order to display concentration in units equivalent to parts per million. This is a two step process. The instrument is first adjusted to a "zero gas" (usually ambient air, away from the contaminated site). If necessary, cylinders of "zero gas" may be purchased. After zeroing, the unit is then calibrated to a "span gas", usually isobutylene at a concentration of 100 ppm. Isobutylene is used because the MICROTIP responds more or less the same to other chemicals as it does to isobutylene. Because the instrument has a medium response to this gas, isobutylene was chosen as a reliable means of reporting an average concentration to total ionizables present.

To calibrate the instrument, use the calibration kit as follows:

1. Connect the regulator to the span gas cylinder. Open the valve on the gas bag by turning the valve stem counter-clockwise. Attach the gas bag to the regulator and open the regulator valve to fill the bag. Keep your finger over the opening in the gas bag tube. When full, close gas bag valve by turning it clockwise.
2. Press SETUP and select the desired Cal Memory with the arrow keys and press ENTER. Press EXIT to leave Setup.
3. Press CAL and expose the MICROTIP to the zero gas. Press ENTER and the instrument sets its zero point.
4. The MICROTIP then asks for the span gas concentration. Enter the known span gas concentration (100 ppm) and then connect the gas bag adaptor to the inlet, open the gas bag valve, keeping your finger over the tube hole.

Press ENTER and the instrument sets its response factor.

5. When the display reverts to normal, the MICROTIP is calibrated and ready for use. Remove the gas bag from the inlet.

The MICROTIP has five calibration memories and can be calibrated with five different gases if desired. Whenever the instrument is calibrated, the selected calibration memory is updated. The instrument should be calibrated once per day.

3. Setup and Use

The SETUP key allows the MICROTIP to be set up for specific application. It will set up the current date and time, the range for the bar graph display and the Cal Memory selection. Press ENTER after each selection.

The ALARM key allows the alarm level to be set. If a contaminant concentration is encountered that exceeds the set alarm level, the display will show "Alarm", and an audio signal is heard through the headphones if the audio alarm is turned on.

Pressing the MAX key will display the maximum concentration encountered along with the event number, the date and the time. This is shown for 15 seconds, then the display returns to normal. Pressing MAX and then CLEAR will reset the MAX register.

The EVENT function can be very useful for later evaluation of the data collected. By changing the event at appropriate times, and recording the event number in the field notes, the readings collected during a certain occurrence may be reviewed. Pressing the EVENT key advances the event number by one. Each time the instrument is turned on, the event number also advances by one. The MICROTIP will record up to 255 events.

The PLAY function allows the review of previous data. The instrument will either play back all recorded data, or begin at any specified Event Number. The playback speed and direction is controlled with the arrow keys. A ">" appears on the display when the data are being played back in the forward direction, and "<" indicates a reverse direction playback. Press ENTER to freeze the display at any time and use the arrow keys to resume playback. Press EXIT to return to the normal display. Note: the MICROTIP is still recording readings while the playback is going on.

The MICROTIP will download its recorded information using the PRINT and GRAPH functions. See the manual for information on these.

**ELECTRICAL CONDUCTIVITY METER
(YSI Model 33)**

USE AND MAINTENANCE OF THE YSI MODEL 33 CONDUCTIVITY/TEMP. METERS

METER OPERATION

1. Make sure the probe is UNPLUGGED from the meter.
2. Adjust meter zero (if necessary) by turning the screw on the meter face so that the meter needle coincides with the zero on the conductivity scale.
3. Calibrate the meter by turning the MODE control to REDLINE and adjusting the REDLINE control so the meter needle lines up with the red line on the meter face. If this cannot be accomplished, replace the batteries.
4. Plug the probe into the probe jack (if the probe has been stored dry, it must be soaked in deionized water for 24 hours before use).
5. Put the probe into the solution to be measured (see PROBE USE).

Temperature

To measure temperature, set the MODE control to TEMPERATURE. Allow time for the probe temperature to equilibrate that of the water before reading. Read the temperature on the bottom scale of the meter in degrees Celsius.

Conductivity

1. Set TEMPERATURE dial to the temperature of the solution to be measured.
2. Switch to the X100 scale. If the reading is below 50 on the 0-500 range, switch to X10. If the reading is still below 50, switch to the X1 scale. Read the meter scale and multiply the reading accordingly (EXAMPLE: if the meter reading is 250 on the X10 scale, $250 \times 10 = 2,500$ micromhos/cm).
3. When measuring on the X100 and X10 scales, depress the CELL TEST button. The meter reading should fall less than 2%. If greater, the probe is fouled and the measurement is in error. Clean the probe according to instructions and remeasure (or try a different probe). NOTE: The CELL TEST does not function on the X1 scale.
4. Rinse the probe thoroughly after the measurement of each sample.
5. Be sure to turn meter off after measurements to conserve battery life. The meter requires two "D" cell alkaline batteries. Replace batteries by removing the four screws on the back of the meter case and opening the back. Make sure batteries are placed in the proper positions.

PROBE USE AND MAINTENANCE

1. Obstructions near the probe can disturb readings. At least two inches of clearance must be allowed from non-metallic underwater objects (like the sides of the sample container). Metallic objects should be kept at least six inches away from the probe.

2. The probe should be gently agitated during measurement to insure the flow of the sample through the probe. This also improves the time response of the temperature sensor.

Probe Storage

The probes should be stored in deionized water. Probes stored this way require less frequent replatinization.

Probe Cleaning

CAUTION: Do NOT touch the electrodes inside the probe. Platinum black is soft and can be scraped off.

When the cell test indicates low readings the probable cause is dirty electrodes. Hard water deposits, oils and organic matter are the most likely contaminants.

For convenient normal cleaning soak the electrodes for 5 minutes with a locally available bathroom tile cleaning preparation such as Dow Chemical "Bathroom and Chrome Cleaner," Johnson Wax "Envy, Instant Cleaner," or Lysol Brand "Basin, Tub, Tile Cleaner."

For stronger cleaning a 5 minute soak in a solution made of 10 parts distilled water, 10 parts isopropyl alcohol and 1 part HCl can be used.

Always rinse the probe thoroughly in tap water, then in distilled or deionized water after cleaning and before storage.

TEMPERATURE/pH METER
(Orion Model SL-2)

**** ORION MODEL SL-2 pH/TEMP METER ****

The pH/temperature meter digitally displays the correct reading when the probe is immersed in the solution to be measured.

OPERATION

1. Remove protective sheath from electrode (probe). Remove protective boot and screw on plastic skirt.
2. Press key of interest on instrument to switch display ON.
3. Select pH or temperature mode by pressing appropriate key.
4. To measure, immerse electrode (probe) in solution.
5. To switch unit OFF, press OFF key.

pH Range Standardization (Calibration of instrument)

Two buffer solutions (pH 7 and pH 4) and a beaker of deionized water are required. To prepare buffers, dissolve pH 7 buffer in 200 ml deionized water and dissolve pH 4 buffer in 100 ml of deionized water.

1. Select temp mode and measure buffer.
2. Select pH mode and immerse electrode in pH 7 buffer. Using end of electrode sheath, adjust 'buffer' control (on side of instrument) until display reads value of pH 7 buffer in step 1. RINSE PROBE IN DEIONIZED WATER.
3. Immerse probe in pH 4 buffer and adjust 'slope' control until display reads value of pH 4 buffer at temperature in step 1. Repeat steps 2-3 until no further adjustments are necessary.

** WASH PROBE IN DEIONIZED WATER BEFORE EACH MEASUREMENT.**

NOTE: If measurements are made in alkaline solutions, use pH 9 or pH 10 buffer in preference to pH 4 in step 3.

TURBIDITY METER

General Operating Instructions:

The accuracy and repeatability of your measurements will be a function of the condition of your standards, your technique, and the quality of the glassware.

Standards

Two standards are supplied with each 2008, and others are available. The standards are used as a reference to allow you to calibrate, or *Standardize*, the instrument. This typically would be done before a series of measurements, or on some other regular basis, as an assurance of the accuracy of your readings. The AMCO™ standards supplied have been carefully manufactured and are guaranteed to be accurate to within $\pm 1\%$. Since the accuracy of your results will depend on these standards the following observations and precautions are important:

1. In an unopened bottle (as supplied) the standards will remain stable indefinitely as long as they are not exposed to excessively hot or cold environments. (Keep between 10°C and 40°C.)
2. Once the seal is broken on the standard, the stability is only guaranteed for nine months thereafter, again based on normal environmental conditions.
3. To ensure the accuracy of the standard, never transfer anything into the bottle (e.g. don't dilute, don't return standards that have been removed, don't combine with other standards, etc.)
4. Do not open the standards in dusty environments, and guard against contaminates entering the bottle while it is open.
5. When transferring the standard to a sample tube be certain that the tube is absolutely clean. A reasonable precaution is to rinse out the inside of the tube with the standard before filling the tube. This wastes a few mL of standard, but will minimize the possibility of contamination.
6. After transferring the standard, promptly cap both the sample tube and the standards bottle.

Technique

The handling of the sample tubes and the preparation of the sample is of utmost importance. The glassware must be clean and defect-free. Scratches and/or abrasions will permanently affect the accuracy of your readings.

A good procedure to follow is the following:

1. Use a clean container to obtain a sample of the liquid to be measured. The volume is not critical; somewhere between 50 and 500 mL is fine. Set the container aside and allow the sample time to equilibrate to ambient temperature, and also to allow any entrained gasses to escape. Keep dust or other airborne contaminates from contact with the sample.
2. When the sample has equilibrated, pour a bit of it into the sample tube as a final rinse, and again shake the excess liquid out. Now fill the sample tube to its neck (See Figure 2), taking care to pour the sample gently down the side to avoid creating any bubbles.

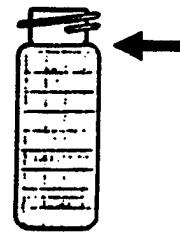


Figure 2

3. Cap the tube and, while holding the tube by the cap only, wipe the outside surface with a clean, lint-free, absorbent wipe until the tube is dry and smudge-free. Handling the tube only by its cap will avoid problems from fingerprints. Set the tube aside on a clean surface that won't contaminate or scratch the bottom of the tube.
4. Select the appropriate range on the 2008, and insert a sample tube containing an AMCO™ standard with a value close to what you suspect the sample you are measuring to be.
5. Be certain the chamber is capped, and that the tube is seated at the bottom of the chamber. The green front panel LED must be illuminated, indicating that the lamp is on. Adjust the *Standardization* control so that the display reads the known value of the chosen standard.
6. Withdraw the standard and insert the tube with the sample to be measured. Again, make sure the chamber is capped and the tube is seated on the bottom. The reading should stabilize within 15 seconds. Make a note of the reading and withdraw the tube.
7. If you wish to take repeated measurements or measure several samples in succession, it will not be necessary to readjust the *Standardization* before each reading. Once set it will remain stable for long periods. Of course you may reinsert the standard at any time to verify the stability of the readings.

Glassware

The variability in the geometry and quality of the glassware is the predominate cause of variability in the readings that will be obtained. With a few precautions to minimize the effects of these variations readings significantly more accurate than the specified $\pm 2\%$ may be obtained.

No piece of glassware is ever perfectly cylindrical (or perfectly like any other). You will notice that if the tube is rotated in the chamber slightly (say in 15° increments) the reading will also vary somewhat. If the tube were always placed into the chamber with the same orientation this source of variability could be eliminated. This can be accomplished if the cap is marked in some way, perhaps with a piece of tape, and always used with the same tube. When inserting the tube with its paired cap you can observe the mark on the cap and always insert it with the same orientation. It is especially useful to do this with the tube used for the AMCO™ standards; any variability in the standardization will affect all subsequent readings.

Once the rotational variability is compensated for the residual uncertainty is a result of how well the tubes match. If absolute accuracy is necessary in your readings it is possible to calibrate the set of tubes supplied with the 2008. The procedure entails filling all the tubes with the same sample, preferably a sample with a turbidity at the upper end of the range you will normally use, and recording the readings for each tube. The value of the readings are irrelevant, but they can be used to derive a correction factor for each tube relative to any other tube. However, if monitoring trends and following small changes is more of a concern, the simple precaution of always using the same tube (in the same orientation) will effectively eliminate the $\pm 2\%$ uncertainty. This assumes, of course, that the tubes used for the AMCO™ standards are not switched either.

Following these precautions can allow the precision and repeatability of your readings to approach $\pm .01$ NTU. Do not forget, however, that since the standardization procedure is based on the AMCO™ standard used, no reading can be considered to be more accurate than $\pm 1\%$ in an absolute sense.

Interpretation of NTU's

Turbidity in a liquid is a result of "suspended solid matter". The presence of "solid matter", usually of a particular nature, results in the scattering of light passing through the liquid which is perceived as a cloudiness in the liquid. Turbid liquid appears cloudy, indeed the cloudy appearance is the definition of turbidity. Turbidity is of interest because it affords an indirect way to evaluate the concentration of the "suspended solid matter". It is indirect in that the solids are not measured; what is measured is their interaction with light.

How a solid particle reacts with (scatters) light depends on the physical characteristics of both the particle and the light. How the scattering is quantified depends on the particular characteristics of measurement procedure or instrument. Historically there have been several different ways to measure, and thus to quantify, turbidity. All yield different results and different numbers. This is not unexpected in a world that cannot agree on a standard for so basic a quantity as distance (inches or centimeters?).

What a NTU is and what it represents is a matter of definition. In part, since NTU is the acronym for Nephelometric Turbidity Units the measurement technique is defined; nephelometry is accepted as referring to the measurement of light scattering in the direction perpendicular to its propagation. The characteristics of the measuring device have been constrained (within rather generous limits) by the requirements of various standards agencies. There is also an accepted standard solution to be used as a calibrated standard. Formazin, formed by reacting hydrazine sulfate with hexamethylenetetramine, is widely used. Unfortunately it is not very stable. Using it as a calibration standard requires reformulating it every few days, which limits its usefulness outside of a laboratory environment.

The 2008 has been calibrated with (and is supplied with) a secondary standard manufactured by Advanced Polymer Systems, Inc. It is a suspension of uniformly sized plastic "microspheres" requiring no preparation, and is stable for long periods. These AMCO® standards are different from Formazin, and so an instrument calibrated on one will necessarily not be calibrated for the other.

In any one type of instrument there is a fixed relationship between the indicated NTU with different standards. For the 2008 that relationship is:

$$\text{NTU Formazin} = 1.25 \times \text{NTU AMCO}^\circledR \text{ or } 0.8 \times \text{NTU Formazin} = \text{NTU AMCO}^\circledR$$

The one equation is just the inverse of the other, and using this relationship you can determine the NTU of any unknown in terms of either Formazin or AMCO® calibration standards. Do not expect, though, that readings made on any one type of instrument will agree with what a different type of instrument indicates. There will be a fixed and determinable relationship between them, but the numerical values need not correspond.

Dilution of Samples

If the sample has a turbidity reading greater than 200 NTU's, it is necessary to dilute the sample with turbidity-free deionized water to bring the reading within the range of the instrument. Turbidity-free deionized water may be prepared as described below. The following calculation is required if the sample is diluted:

$$\frac{A(B + C)}{C} = D$$

where A = NTU found in diluted sample

B = Volume of deionized dilution water used, mL

C = Sample volume taken for dilution, mL

D = NTU of original, undiluted sample

For example: If 10 mL of sample water is diluted with 90 mL of turbidity-free water to a total volume of 100 mL and the resulting solution measures 40 NTU, the turbidity of the original undiluted sample is:

$$\frac{40(90 + 10)}{10} = 400 \text{ NTU}$$

Preparation of Turbidity-Free Water

The preparation of turbidity-free water requires careful technique. Introduction of any foreign matter will affect the turbidity reading. A filtering device with a special membrane filter is incorporated into the procedure to prepare turbidity-free water. The filter, filter holder, and syringe must be conditioned by forcing at least two syringe loads of deionized water through the filtering mechanism to remove foreign matter from the filtering apparatus. The first and second rinses are discarded. Turbidity-free water as prepared below may be stored in the dark at room temperature in a clear glass bottle with screw cap or in a turbidity tube (Code 0273) and used as required. The storage vessels should be rinsed thoroughly with filtered deionized water. Periodically inspect the water for foreign matter in bright light.

Note: The membrane filters are white and packaged between two blue protective disks. Handle membrane filters with extreme care.

Procedure

1. Unscrew the top of the filter holder and place a white membrane filter on the screen inside. The filter disc should be positioned carefully so that it covers the entire surface of the screen. Replace the top of the filter holder and screw on securely.
2. Remove the plunger from the syringe, then attach the filter holder to the bottom of the syringe.
3. Pour approximately 50 mL of deionized water into the barrel of the syringe. Replace plunger into barrel and exert pressure on the plunger to slowly force the water through the filter. Collect the water in a suitable clean container.
4. Remove filter holder from syringe, then remove plunger from barrel. This step is required to prevent rupturing the membrane filter by vacuum as the plunger is removed from the barrel.

5. Replace filter holder and repeat steps 3 and 4 until the desired amount of turbidity-free water is collected. Periodically examine the membrane filter to insure no holes or cracks are evident.
6. Depending upon the nature of the unfiltered water it is possible to prepare a liter or more of turbidity-free water using a single filter. The membrane filter may be stored in the holder for an indefinite period of time and used as required.

Maintenance

No periodic maintenance is required. The most important considerations in assuring long life and accurate readings are:

1. Keep the instrument clean and dry, especially the sample chamber. Keep the chamber capped except while inserting or removing sample tube. If the chamber needs to be cleaned the best first choice is compressed gas. Photo-supply outlets sell an "aerosol" can of clean and dry gas for cleaning lenses - this is ideal. Hold the 2008 upside down while "squirting" it so that the particles will fall out and not be forced further into the bottom of the chamber.
2. Be aware that the lamp will eventually "burn out", though its estimated service life in normal use is in excess of 10 years. It is not user serviceable because the type of lamp used is not commonly available and its placement critically effects the calibration and so it is best replaced at the LaMotte Service Laboratory where the necessary calibration equipment is available. But also note that the lamp may become unstable and/or excessively dim well before it actually fails. A good test of lamp stability is to observe the display with a clean, dry and empty sample tube in the chamber. The actual value under these conditions is unpredictable (it will probably be between 1.50 and 3.00 NTU) but it should be stable (± 0.02 NTU). As long as the display is stable the lamp is useable.
3. Likewise the battery life is finite, though it is harder to estimate, since it is a function of use history and environmental conditions. As a rule, if A.C. power is available use it instead of the battery. If the instrument is used occasionally (once a month or less) it will maximize battery life if the function switch is left in the "Charge" position. Another useful practice is to continue using battery power only, once the instrument had been disconnected from the A.C. adaptor, until the battery low indicator is visible. Recharging from the fully discharged condition (Bat low indicator visible) to the fully charged condition (red LED extinguished) should take 4 to 5 hours. If it takes notably less than that it is a sign of diminished battery capacity. Note that the 2008 may be used with the A.C. adaptor even with totally exhausted and/or "worn out" batteries. If the battery capacity diminishes to the extent that they are no longer able to make as many measurements as you need between charging cycles return the instrument (see instructions for "Returns") for battery replacement

The lamp is only illuminated when the instrument is in the measurement mode and a sample tube is seated in the bottom of the chamber. Since the readings are valid within 15 seconds there is no need to allow the lamp to be illuminated any longer than necessary to take a measurement. Battery life and lamp life will both be enhanced by always removing the sample from the chamber after the measurement is recorded.

APPENDIX C

ASTM FIELD LOGGING STANDARDS

TECHNICAL NOTE

Amster K. Howard¹

The Revised ASTM Standard on the Unified Classification System

REFERENCE: Howard, A. K., "The Revised ASTM Standard on the Unified Soil Classification System," *Geotechnical Testing Journal*, GTJODJ, Vol. 7, No. 4, Dec. 1984, pp. 216-222.

ABSTRACT: ASTM Test Method for Classification of Soils for Engineering Purposes (D 2487) was significantly revised in 1983. The revisions require that soil is to be classified by using both a symbol and a name, and the group names were standardized. Organic silts and clays were redefined to recognize that organic soils occur that plot above the "A" line on the plasticity chart. More precise guidelines were established, particularly with regard to plasticity, so that only one particular classification will result. If borderline classifications are used, the classification symbols are separated with a slash with the classification symbol indicated using the standard appearing first. Appendixes give example written descriptions, preparation of soil for testing, and guidelines for using the system for materials such as shale, mudstone, crushed rock, and slag.

KEYWORDS: soil classifications, soils, sands, clays, silts

Introduction

Classification is the mirror in which the present condition of science is reflected; a series of classifications reflect the phases of its development, Aristocristane, 98 A.D.

ASTM Test Method for Classification of Soils for Engineering Purposes (D 2487) was significantly revised in 1983. The modifications were the result of several years of discussion by ASTM Subcommittee D18.07 on Identification and Classification of Soils and a special meeting of Federal agencies using the Unified Soil Classification System (USCS) held in Denver, CO, in 1980.

The USCS has become the most popular and widely used soil classification system for engineering purposes. The Federal Aviation Administration (FAA) recently adopted the use of the USCS in place of the system they had developed earlier. Personnel using the American Association of State Highway and Transportation Officials (AASHTO) soil classification system for highway construction are seriously looking at using the USCS. The USCS began as the Airfield Classification System developed by Arthur Casagrande during World War II. With the adoption of the system by the U.S. Bureau of Reclamation and the Corps of Engineers in 1952, with standardized terms and procedures, it became known as the "Unified" system.

¹Supervisory civil engineer, U.S. Bureau of Reclamation, Code 1542, P.O. Box 25007, Denver, CO 80225. Member of ASTM.

In the ensuing years, it became apparent that certain approaches in the system needed to be better defined and standardized. Where insufficiencies or gaps existed, various organizations and agencies found it necessary to develop their own standards or practices. In an attempt to bring uniformity to this important means of communicating engineering information, ASTM Subcommittee D18.07 sought to refine and standardize the ASTM version of the system.

The significant changes and revisions adopted include the following:

1. Soil classification consists of both a name and a symbol.
2. The names were standardized.
3. Organic silts and clays were redefined.
4. More precise classification was established.

In addition, information presented in appendixes gives example written descriptions to encourage uniformity, detail methods of preparation and testing, and shows how the system can be used to assist in describing materials such as shale, siltstone, crushed rock, and so forth.

ASTM Recommended Practice for Description of Soils (Visual-Manual Procedure) (D 2488-69) is currently undergoing similar revisions.

Classification—Name and Symbol

The classification of a soil should consist of both a name and a symbol. Often only a symbol is used, and this can be misleading. For example, the symbol CL is used for the following three soils:

- (1) 100% fines,
- (2) 55% fines, 45% fine-to-medium sand, and
- (3) 55% fines, 25% fine and coarse gravel, 20% fine to coarse sand.

These are three different materials based on their gradation and on their engineering properties. The new ASTM D 2487-83 would classify the soils as follows:

- (1) CL—lean clay,
- (2) CL—sandy lean clay, and
- (3) CL—gravelly lean clay with sand.

It is obvious that the name and symbol together give a better indication of what the soil is like.

MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW Well-graded gravels and gravel-sand mixtures, little or no fines
			GP Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES	GM Silty gravels, gravel-sand-silt mixtures
			GC Clayey gravels, gravel-sand-clay mixtures
		CLEAN SANDS More than 50% of coarse fraction passes No. 4 sieve	SW Well-graded sands and gravelly sands, little or no fines
			SP Poorly graded sands and gravelly sands, little or no fines
			SM Silty sands, sand-silt mixtures
			SC Clayey sands, sand-clay mixtures
			ML Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
FINE-GRAINED SOILS 50% or more passes No. 200 sieve*	SILTS AND CLAYS Liquid limit 50% or less	CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL Organic silts and organic silty clays of low plasticity
			NH Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		CH Inorganic clays of high plasticity, fat clays	CH Inorganic clays of high plasticity, fat clays
			OH Organic clays of medium to high plasticity
	HIGHLY ORGANIC SOILS	PT Peat, muck and other highly organic soils	

* Based on the material passing the 3-in. (75-mm) sieve.

FIG. 1—Soil classification chart (ASTM D 2487-69).

Standardization of Group Names

On Figure 1 of ASTM D 2487-69 (see Fig. 1, this paper), one column of the soil classification chart shows "group symbols" and the adjacent column "typical names." The typical names were more like descriptions of the soil, but some of the descriptions evolved in time to become a name associated with the symbol. The committee decided to formalize these names with a single unique name for each symbol (except for organic silts and clays). The names and corresponding symbols are:

- GW well-graded gravel
- GP poorly graded gravel
- GM silty gravel
- GC clayey gravel
- SW well-graded sand
- SP poorly graded sand
- SM silty sand
- SC clayey sand
- CL lean clay

ML	silt
OL	organic silt or organic clay
CH	fat clay
MH	elastic silt
OH	organic silt or organic clay
PT	peat

Although some of the names were often unpalatable (for example, fat clay and elastic silt), it was decided to go with the vernacular that had evolved, recognizing that it would be impossible to change.

In addition, modifiers to the basic group name were standardized. Most engineering organizations recognized the need to change the soil name or modify it to better reflect the characteristics of the soil. However, the names varied widely between users. For example, soil with 20% sand, 15% gravel, and 65% fines has been variously described as:

- lean clay,
- sandy clay,
- sandy gravelly clay,
- sandy lean clay,
- sandy gravelly lean clay,
- lean sandy clay,
- lean clay with sand and gravel, or
- clay with well-graded sand and gravel.

Since only the symbol, CL, does not convey enough information, a group name should be associated with the symbol and that group name should be standardized. According to the revised standard, every user would describe this soil as

sandy lean clay with gravel, CL

Thus, the name and symbol alone relate the facts that the fines are clayey with a liquid limit less than 50; there is between 30 and 49% coarse-grained particles, predominantly sand, with at least 15% gravel.

The standard group name is listed in Table 1 of the new standard (see Fig. 2, this paper) for each group symbol and information given as to what to add to the group by a "with" statement. The flow charts, Figs. 1 and 2, also illustrate the use of the group name and "withs" (see Figs. 3 through 5, this paper).

Organic Silts and Clays Redefined

In ASTM D 2487-69, organic silts (OL) and organic clays (OH) could only occur below the "A" line. A liquid limit of 50 was the dividing line between OL and OH (see Fig. 1 ASTM D 2487-69).

The standard was changed so that OL and OH soils can be both below and above the "A" line. A liquid limit of 50 remains as the division between the symbols OL and OH (see Fig. 6, this paper). However, the group name will depend on whether the soil plots above or below the "A" line. The group names "organic clay" will apply to soils on or above the "A" line and "organic silt" will apply to soils below the "A" line. The possible classifications then are

- organic clay, OL
- organic silt, OL
- organic clay, OH, or
- organic silt, OH

The criterion for determining whether or not a soil is organic remains as the comparison of the liquid limit values of an oven-dried

specimen and a nondried specimen. The change was made for the following reasons:

1. Organic soils occur that plot above the "A" line. The following comments are by A. Casagrande [1].

Originally the A-line was defined by the writer as an empirical boundary between typical inorganic clays and plastic organic soils. He was then not aware of the existence of fairly tough organic clays which fall above the A-line. (They have more the characteristics of inorganic clays except for the substantial loss in plasticity due to drying.) It was suggested to move the A-line so as to assure that all organic soils would fall below it. However, this would also bring most inorganic soils below the A-line. The writer believes that the A-line has proven its value as an important reference line and that it should be kept essentially in its original position, but, that in the expanded system a new group should be provided for the organic soils located above the A-line.

The following are comments by R. A. Barron [2]:

After a year's use, comments were sent in from the various field offices to the Office of the Chief of Engineers. There were a few comments on the system which indicated some minor revisions may be necessary. One, for

instance, is the fact that some organic soils plot above the "A" line of the plasticity charts.

In addition, Richard S. Ladd, of Woodward-Clyde Consultants of Clifton, NJ, reported in subcommittee meetings of D18.07 that his laboratory has encountered organic soils that plot above the "A" line.

2. For inorganic soils, the "A" line is the division between clays and silts. This division is now logically extended to organic soils.

3. The name "organic clay" according to ASTM D 2487-69 could have been applied to a soil with a liquid limit (LL) > 50 and a plasticity index (PI) < 10. For a soil with such low plasticity, the name organic "clay" is inappropriate.

More Precise Classification

ASTM D 2487-69 recommended giving a soil a borderline classification if the LL and PI values plotted "on or practically on" the "A" line or the LL = 50 line.

CRITERIA FOR ASSIGNING GROUP SYMBOLS AND GROUP NAMES USING LABORATORY TESTS ^a				SOIL CLASSIFICATION		
		GROUP SYMBOL	GROUP NAME ^b			
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS Less than 5% fines ^c	$C_u \geq 4$ and $1 \leq C_c \leq 3$ ^e	GW	Well-graded gravel ^f	
			$C_u < 4$ and/or $1 > C_c > 3$ ^e	GP	Poorly graded gravel ^f	
		GRAVELS WITH FINES More than 12% fines ^c	Fines classify as ML or MH	GM	Silty gravel f,g,h	
			Fines classify as CL or CH	GC	Clayey gravel f,g,h	
		CLEAN SANDS Less than 5% fines ^d	$C_u \geq 6$ and $1 \leq C_c \leq 3$ ^e	SM	Well-graded sand ⁱ	
	SANDS 50% or more of coarse fraction passes No. 4 sieve		$C_u < 6$ and/or $1 > C_c > 3$ ^e	SP	Poorly graded sand ⁱ	
		SANDS WITH FINES More than 12% fines ^d	Fines classify as ML or MH	SM	Silty sand g,h,i	
			Fines classify as CL or CH	SC	Clayey sand g,h,i	
		PI > 7 and plots on or above "A" line ^j		CL	Lean clay k,l,m	
		PI < 4 or plots below "A" line ^j		ML	Silt k,l,m	
FINE-GRAINED SOILS 50% or more passed the No. 200 sieve	SILTS AND CLAYS Liquid limit less than 50%	inorganic	Liquid limit - oven dried < 0.75 Liquid limit - not dried	OL	Organic clay k, l, m, n Organic silt k, l, m, o	
		organic	PI plots on or above "A" line	CH	Fat clay k,l,m	
		inorganic	PI plots below "A" line	MH	Elastic silt k,l,m	
	SILTS AND CLAYS Liquid limit 50% or more	organic	Liquid limit - oven dried < 0.75 Liquid limit - not dried	OM	Organic clay k, l, m, p Organic silt k, l, m, q	
		inorganic				
		organic				
Highly organic soils		Primarily organic matter, dark in color, and organic odor				

- a. Based on the material passing the 3-in (75-mm) sieve.
- b. If field sample contained cobbles and/or boulders, add "with cobbles and/or boulders" to group name.
- c. Gravels with 5 to 12% fines require dual symbols
GW-GW well graded gravel with silt
GW-GC well graded gravel with clay
GP-GW poorly graded gravel with silt
GP-GC poorly graded gravel with clay
- d. Sands with 5 to 12% fines require dual symbols
SM-SH well graded sand with silt
SM-SC well graded sand with clay
SP-SH poorly graded sand with silt
SP-SC poorly graded sand with clay
 $(D_{50})^2$
- e. $C_u = D_{50}/D_{10}$ $C_c = D_{10}^2/D_{50}$
- f. If soil contains > 15% sand, add "with sand" to group name.
- g. If fines classify as CL-ML, use dual symbol GC-GW, SC-SH.
- h. If fines are organic, add "with organic fines" to group name.
- i. If soil contains > 15% gravel, add "with gravel" to group name.
- j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
- k. If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
- l. If soil contains > 30% plus No. 200, predominantly sand, add "sandy" to group name.
- m. If soil contains Σ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
- n. PI > 4 and plots on or above "A" line.
- o. PI < 4 or plots below "A" line.
- p. PI plots on or above "A" line.
- q. PI plots below "A" line.

FIG. 2—Soil classification chart (ASTM D 2487-83).

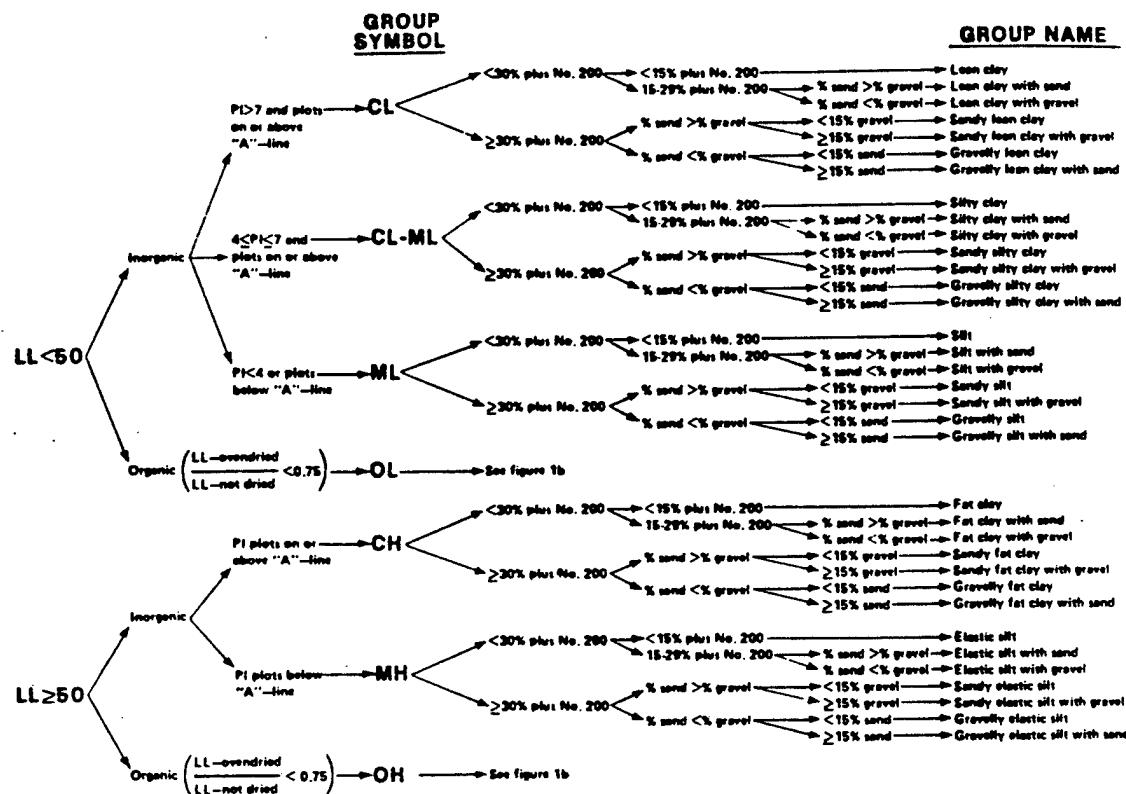


FIG. 3—Flow chart for classifying fine-grained soil.

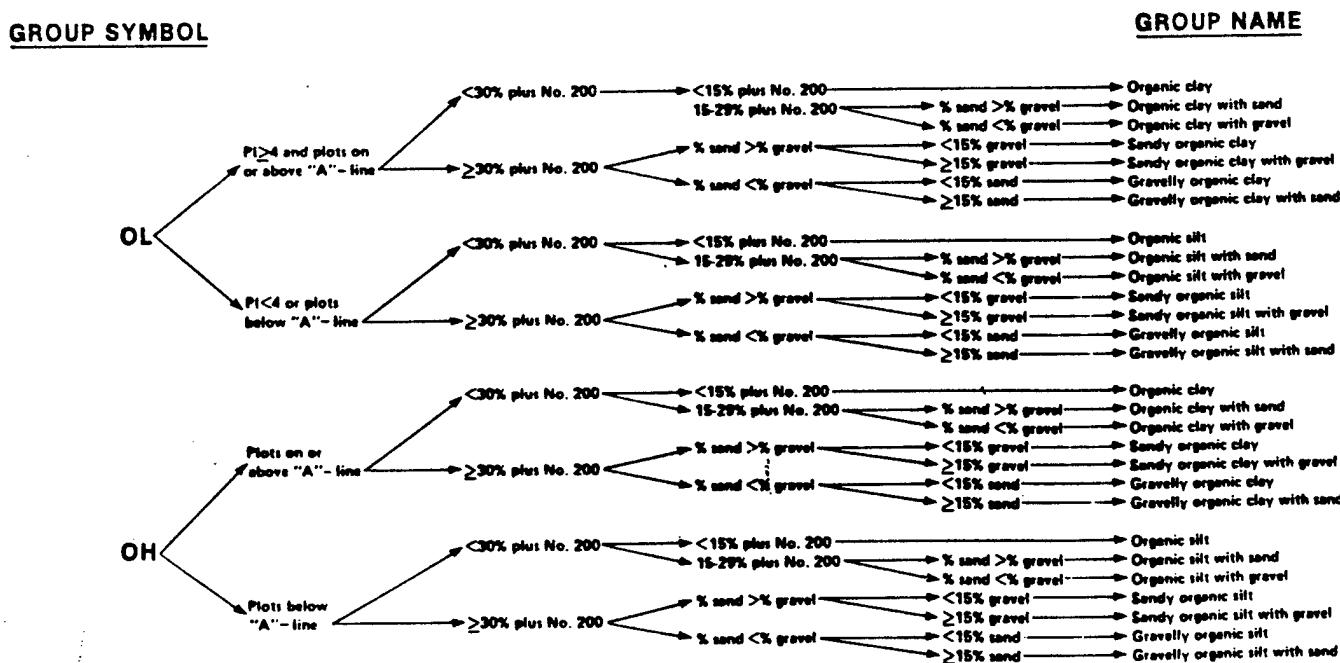


FIG. 4—Flow chart for classifying organic soils.

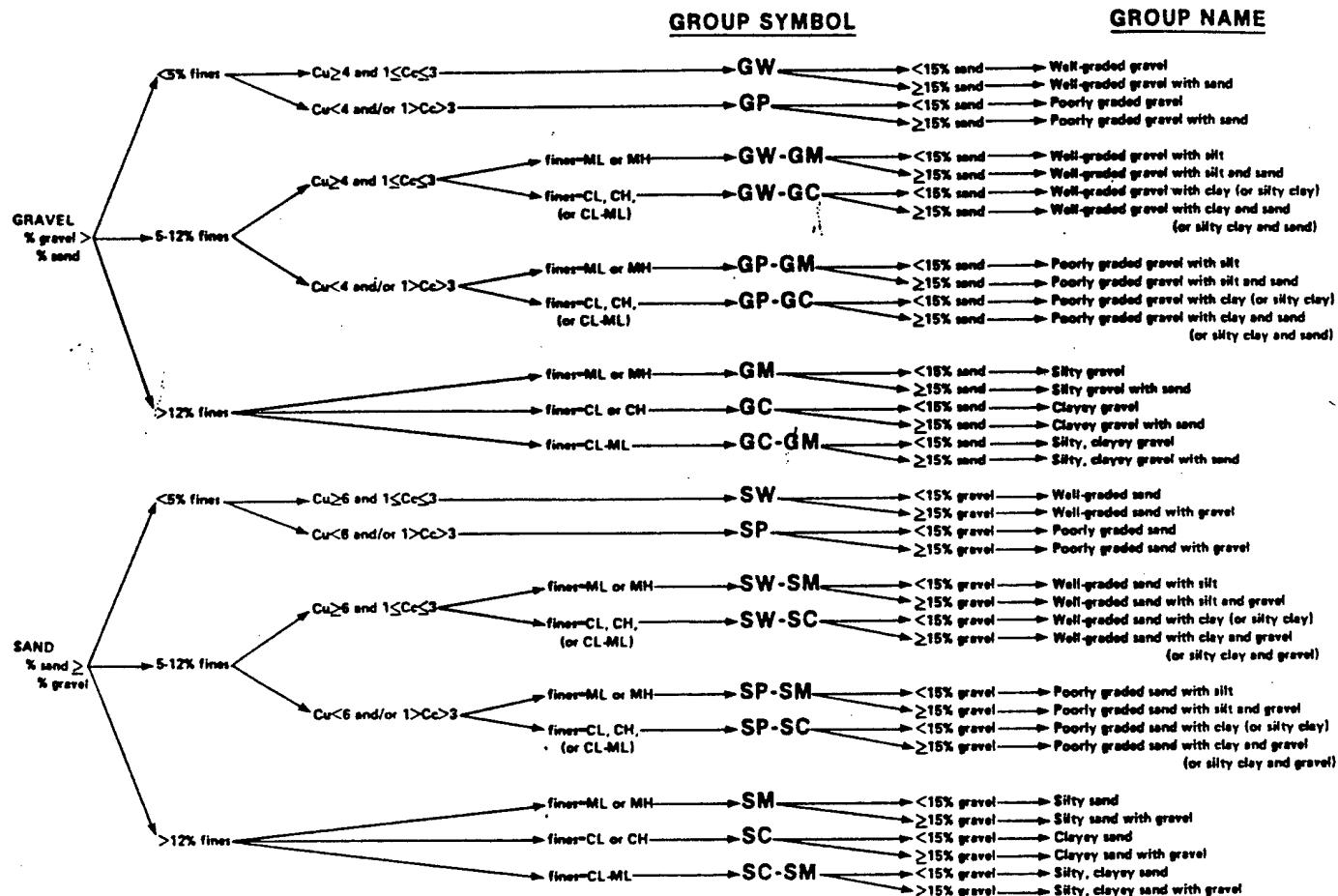


FIG. 5—Flow chart for classifying coarse-grained soil.

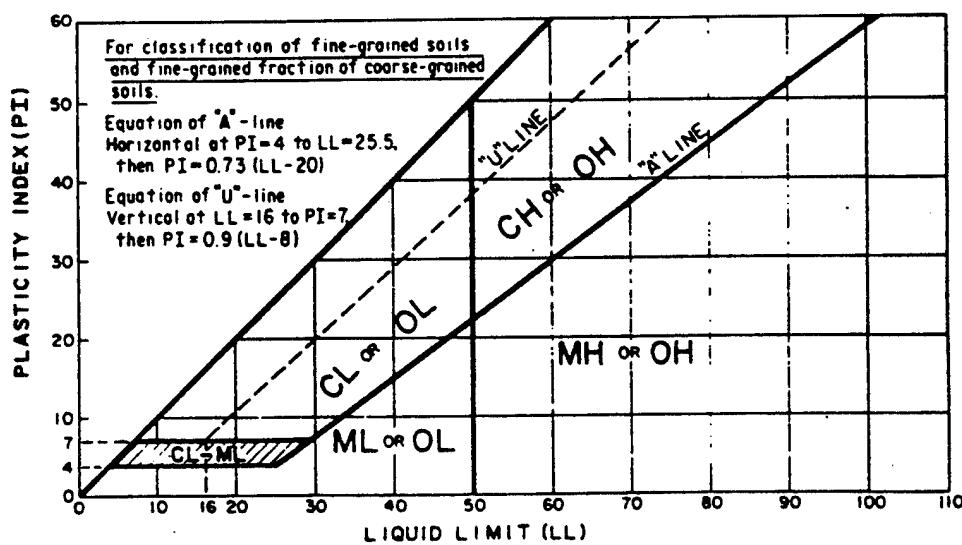


FIG. 6—Plasticity chart.

The standard was changed so that these borderline classifications are eliminated. Fines to be described as clay have an LL and PI value that plot on or above the "A" line while fines to be described as silt would plot below the "A" line. The symbols CH, MH, and OL refer to soils with a liquid limit of 50 or greater; and CL, ML, and OL refer to soils with a liquid limit less than 50.

The change was made for the following reasons:

- (1) to eliminate the confusion and profusion of using borderline classifications,
- (2) so people using the same laboratory test results would classify the soil exactly the same, and
- (3) so inexperienced personnel and computer programs would have a set of prescribed rules to follow.

Dual Versus Borderline Symbols

The USCS requires some soils to have dual symbols. Soils with 5 to 12% fines must have a dual symbol composed of a clean, coarse-grained symbol followed by a coarse-grained soil with fines symbol (for example, SP-SM and GW-GC). Soils with LL and PI values that plot in the cross-hatched area of the plasticity chart must have a dual symbol of CL-ML, SC-SM, or GC-GM. These classifications are a required part of the system as presented in ASTM D 2487-83.

However, it is often desired to indicate that a soil is close to the boundary or borderline between two different soil classifications. When the laboratory tests indicate that a soil is close to a borderline (either plasticity or gradation values), it can be given a borderline symbol of two symbols separated by a slash. The first symbol is the one based on ASTM D 2487 (for example, CL/CH, CL/ML, ML/CL, and GP/SP).

Emphasis Placed on More Plastic Classification

The new standard emphasizes or favors the more plastic classification or the finer-grained classification.

1. ASTM D 2487-69 defined fine-grained soils as "50% or more passes the No. 200 sieve" and coarse-grained soils as "more than 50% retained on No. 200 sieve" while sands were soils with "more than 50% of coarse fraction passes No. 4 sieve" and gravels as "50% or more of coarse fraction retained on No. 4 sieve." In the former case, the fine-grained material was favored while in the latter case the coarse-grained material was favored. The new standard changes the latter case to describe sands as "50% or more of coarse fraction passes the No. 4 sieve" and gravels as "more than 50% of coarse fraction retained on No. 4 sieve."

2. ASTM D 2487-69 favored the less plastic classification in one note (Note 5), while another note (Note 6) stated the more plastic classification was to be favored.

The new standard favors the more plastic classification in the following ways:

1. New Note 7 (old Note 5) was changed to favor the more plastic classification.
2. When the LL and PI for a soil fall on the "A" line, the soil is classified as a clay, not a silt.
3. When the LL = 50, the soil is to be classified as a CH, not CL, and MH, not ML, emphasizing the more compressible material.
4. A soil with LL and PI plotting in the hatched area of the plasticity chart is to be classified as a CL-ML, silty clay.

Use of the System as a Secondary Classification System

The USCS is often used for classifying and describing materials such as shale, siltstone, claystone, mudstone, sandstone, crushed rock, slag, cinders, shells, and so forth.

Lithified or partially lithified material (shale, claystone, and so forth), is sometimes classified as a soil after the material has been processed (grinding, slaking, and so forth). The material should be "classified" according to its original state. A secondary classification according to USCS can be reported. However, as presented in Appendix X2 in ASTM D 2487-83, it is suggested that the group name and symbol be in quotation marks to distinguish them from the classification of true soils.

Material, such as shells and slag, should not be considered as soil, but the USCS can be used to describe the material. Again, the primary classification should be shells or slag with a secondary USCS classification in quotation marks.

Crushed rock is not a naturally occurring soil and any classification should also be in quotation marks.

Examples of written descriptions were included in Appendix X2, some of which are shown below:

1. *Shale Chunks*—retrieved as 50- to 101-mm (2- to 4-in.) pieces of shale from power auger, dry, brown, no reaction with HCl. After laboratory processing by slaking in water for 24 h material classified as "Sandy Lean Clay (CL)," 61% clayey fines, LL = 37, PI = 16; 33% fine to medium sand; 6% gravel-size pieces of shale.

2. *Crushed Rock*—processed gravel and cobbles from Pit 7; "Poorly Graded Gravel (GP)," 89% fine, hard, angular gravel-size particles; 11% coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl; Cc = 2.4, Cu = 0.9.

"U" Line

The upper limit or "U" line was added to the plasticity chart (Fig. 6) to aid in the evaluation of test data. This line was recommended by Casagrande as an empirical boundary for natural soils. It provides a check against erroneous data, and any test results that plot above or to the left of it should be verified.

There is no formal documentation as to the origin of the "U" line. Students in classes given by Casagrande reported that it was presented as part of his lectures, and they have the sketch in their class notes. The Corps of Engineers does include the "U" line, described as the upper limit line, in their manual *Laboratory Soils Testing*. Casagrande served as a consultant for this manual and did review it. The Corps' manual states that the "U" line begins at an LL of 8 and PI of 0 and rises on a slope of 0.9 (PI - 0.9 [LL = 8]). However, the line is not shown on their plasticity chart below a PI of 7 (the top of the cross-hatched area).

The 1983 revision of ASTM D 2487 also shows the "U" line on the plasticity chart, but below a PI of 7 the line is vertical at LL = 16. LL's below 16 are felt to be unreasonable values as the soil is probably sliding on the surface of the cup rather than a flowing or shearing of the material. A computer search revealed that of over a thousand soil specimens tested and reported by the USBR geotechnical laboratory, four had LL = 17, one had LL = 16, and none had LL below 16.

Expanded Liquid Limit Scale

Stopping the LL scale at 100 on the plasticity chart tends to reinforce the erroneous assumption that the LL of a soil cannot be greater than 100. Expanding the scale to 110 to help correct this mis-

understanding was incorporated in the 1983 revision of ASTM D 2487 (Fig. 6).

Symbol for Coefficient of Curvature

The most controversial change in the revised standard was the symbol for the coefficient of curvature. In the USCS, as adopted by the Corps of Engineers and the Bureau of Reclamation, the symbol used was C_c . Unfortunately, this is also the soil mechanics symbol for the compression index; the slope of the linear portion of the pressure-void ratio curve on a semilog plot. In ASTM 2487-69, the symbol C_2 was used for the coefficient of curvature in order to avoid the confusion of using the same symbol for two different terms. During the balloting process preceding the 1983 version, it became apparent that a strong and vociferous faction wanted to return to the traditional C_c as the symbol. After a ballot incorporating the C_c symbol went out, it became obvious that the advocates of not using the C_c symbol were also indeed numerous and vocal. Following hours of deliberating, cogitating, and arbitrating, the symbol C_c , with the lower case c on the same line (not a subscript) was selected as the symbol that least offended all the parties involved.

Cobbles and Boulders

Although the soil that is classified is the 75-mm (3-in.) minus material, the new standard requires that if plus 75-mm (3-in.) particles (cobbles or boulders) were present in the field sample, then the name of the soil should reflect their presence (for example, silty gravel with cobbles, GM). Suggested criteria for what is a cobble or a boulder were given.

Summary

ASTM D 2487 was significantly revised in 1983. The revisions include:

1. Requiring soil to be classified by stating both a symbol and a name.
2. Standardizing the names associated with the symbols and what modifiers or additional terms must be included in the name.
3. Redefining organic silts and clays to recognize that organic soils occur that plot above the "A" line on the plasticity chart.
4. More precise guidelines were established, particularly with regard to plasticity, to eliminate borderline classifications. Using the standard, only one particular classification will result. In the case of soils with 5 to 12% fines or plotting in the hatched area of the plasticity chart, dual symbols are used (for example, SP-SM, and CL-ML). However, if it is desired to indicate that the soil properties are close to another classification group, the two groups can be indicated using a slash, for example, CL/CH, with the classification indicated from the standard appearing first.
5. Provision was made to apply the classification system to materials such as shale, mudstone, crushed rock, slag, and so forth.

References

- [1] Casagrande, A., "Proposal for a Unified Soil Classification," U.S. Bureau of Reclamation, no date.
- [2] Barron, R. A., "Discussion of 'A Standard Classification of Soils as Proposed by the Bureau of Reclamation' by E. A. Abdun-Nur," *Symposium on the Identification and Classification of Soils, STP 113*, American Society for Testing and Materials, Philadelphia, 1950, p. 6.